Brain/Lung/Breast Cancer Detection

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1 Introduction

1.1 Purpose of this document

The purpose of this software requirements specification document is to present the requirements for Brain, Lung and breast cancer detection. And Breast dense calculation. The main requirements for this software were to be able to identify whether the patient has any kind of these cancers or not. Calculating breast dense could help in prediction of breast cancer on the long term.If the patient happens to have a cancer then it should be segmented accurately as it has been found that it is a common problem to most of the doctors to identify the exact size and location of the tumor.

1.2 Scope of this document

This document targets the doctors which will integrate with this software. The scope of our project focuses on the Magnetic Resonance Image (MRI), Computed Tomography (CT) and Mammography.

1.3 Overview

In Figure 1, Our project aims to read three different types of images which are breast (Mammography), lung (CT scan) and Brain (MRI) cancer in order to solve the problem of time consuming, low accuracy and conflicting results which varies from doctor to another. This is going to be achieved through image processing techniques in order to determine tumor size and location but with different order according to each type of image given to system.

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•Brain : MRI image is given and start with preprocess, such as applying median , gaussian and average. Feature extraction is applied by using normalized histogram for calculation of beta and gamma to detect the patient's status (tumor or non-tumor). After that the cancerous image is segmented using kmeans,threshold and average.

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•Breast: Mammography image is given to the system through preprocess - as a first step - in order to remove artifacts and pectrol if found. after that the image is segmented by taking the values of interest. Feature extraction is applied including some statistics that can be passed through the classification step takes place by using svm to obtain results of new images passed by doctor.

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•Lung: Ct Scan image is passed through stages. By applying preprocess techniques including threshold, binary closing and labeling in order to segment slices of each patient. Feature extraction is applied with the help of u-net candidate in order to distinguish pixel values of nodules which are (0 or 1). Classification step takes place here in order to distinguish cancerous nodules from normal blood cells for each slice. CNN Classifier can then take all slices for all patients to obtain 3d model and predict the patient is cancerous or not.

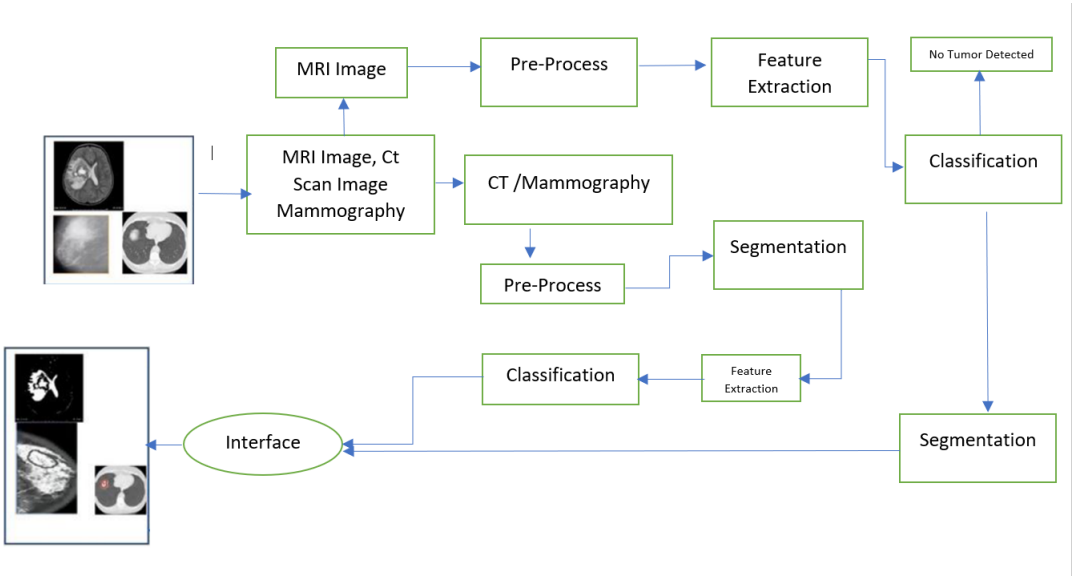

Figure 1: System Overview

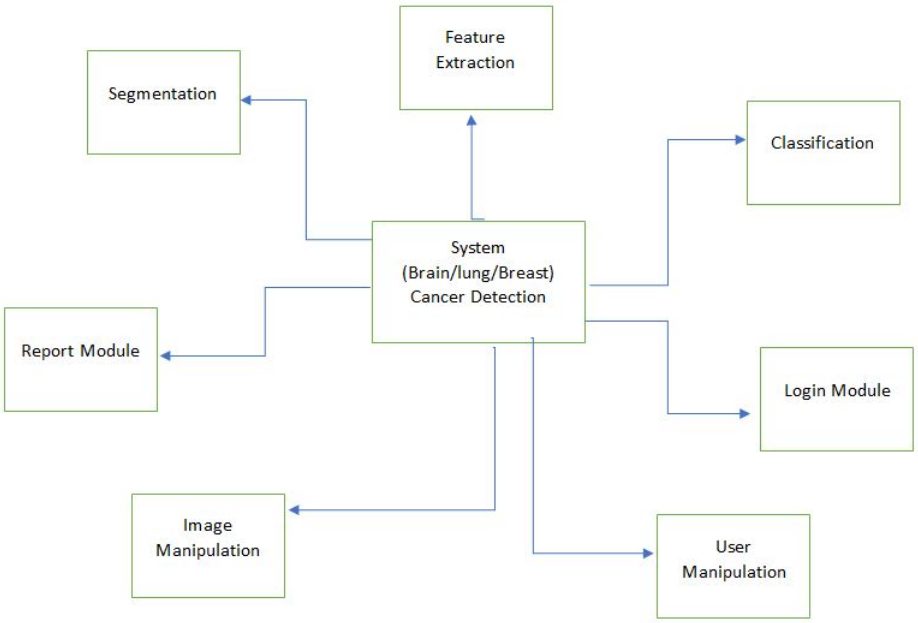

Figure 2: Block Diagram

Block Diagram in Figure 2 represents:
• Login Module: Is the module responsible for the login operation of admin and doctor.

• User Manipulation Module: Is the module responsible for the adding/searching/deleteing/editing Doctors and patients.

• Image Manipulation Module : Is responsible for handling the image with the operations required to be done on this image.

•Report Module: Handles the report generated by the doctor.

• Feature Extraction Module : Responsible for extracting the features required to train dataset from the image.

• Classification Module : Is responsible for the classification of the input image as cancer/not cancer.

• Segmentation Module: Responsible for the segmentation of the tumor parts in the input image.

1.4 Business Context

As a matter of a fact identification of tumor/non-tumor patient - the size and location of the tumor if found - can differ from one doctor to another according to their experiences, their back knowledge and the patient's medical history. Our system allows any doctor to be an experienced doctor as it is no longer a manual process it is a brief of complex operations that raises the accuracy of tumor detection which increases continuously. And as a conclusion it is about saving lives through high efficiency and low time consumption.

2 General Description

2.1 Product Functions

• Login Module:
-Admin/ Doctor can access the system using username and password.
-After filling current username and password Admin/Doctor can access certain features/Pages.

• User manipulation module:
-Doctor can add Patient including (Personal Data , Scanned Image).
-Doctor can search for a patient if it is already added.
-Doctor can edit after getting record of patient including(Personal data, scanned image).
-Doctor can delete patient from system.
-Admin can add/delete/edit doctors .
-Doctor can check for results of scanned image obtained from system.

• Image Manipulation Module:
-Doctor can upload patient's image to the system to be visible.
-Doctor can search/delete a patient's image after obtaining the patient's data.
-Doctor can choose operation according to type of image (Segmentation and Classify if its a cancer or not and if the image is breast classify breast dense).

• Report Module:
-Doctor can edit in personal information of patient.
-Doctor can generate report with the final status of patient(cancerous or not).
-Doctor can save reports of several patients.

•Segmentation Module: -System can take the input image from Doctor and apply some filters to help in segmentation process.
-System can apply functions to remove artifacts from the image.
-System can exclude certain pixels to enhance image while applying filters.
-System can output the segmented tumor parts if found.

•Feature Extraction module.

-System can apply formulas to calculate values from images according to it's type (cancerous or not) .
-System can pass these features for classification.

•Classification module:.
-System can apply preprocess functions and feature extractions and compare with training labels such as excel files, images.
-System can train on these given samples to classify new input.
-New input image can iterate in same preprocess cycle to obtain result.

2.2 Similar System Information

• Brain:

Magnetic resonance imaging (MRI) is a technique which is used for the evaluation of the brain tumor in medical science. In this paper [4], they did a study to classify whether the patient has a tumor or not by using some preprocessing techniques such as Median filter, Adaptive filter, Averaging filter, Un-sharp masking filter and Gaussian filter is used to remove the additive noises present in the MRI images after applying these filters, they applied the Normalized histogram. For implementation MATLAB is used. The images were classified into 'tumor image' and 'non-tumor image' after histogram normalization using Naïve Bayes classifier and SVM. Efficiency of SVM = 91.49 percent and Naïve Bayes = 87.23 percent. It is concluded that SVM has given better efficiency than Naive Bayes classifier. If the patient has a tumor then it is segmented using K means segmentation and edge detection. The proposed method has some limitations because in some tumor images, the results were not satisfactory, the detection of tumor was not accurate.

This flow chart in Figure 3 represents the preprocessing steps of this paper [4] after the preprocessing is finished it is delivered to the classifiers mentioned before and if the image is classified as a tumor it is delivered to segmentation process which specifies the location of the detected tumor. If the image is classified as non-tumor then the process is finished.

• Lung:

Deep Convolutional neural network for lung cancer detections has achieved a lot of steps in order to detect tumor using three major phases (segmentation, nodule candidate detection, and malignancy classification) allowing more efficient training and detection. This is achieved by containing nodule or not which is less than 10 mm in diameter for early stage cancer. Their goal in this paper [1] is to construct a computer-aided diagnosis (CAD) system that takes as input patient chest CT scans and outputs whether or not the patient has lung cancer. Identifying regions of interest, they train a Unet for nodule candidate detection.

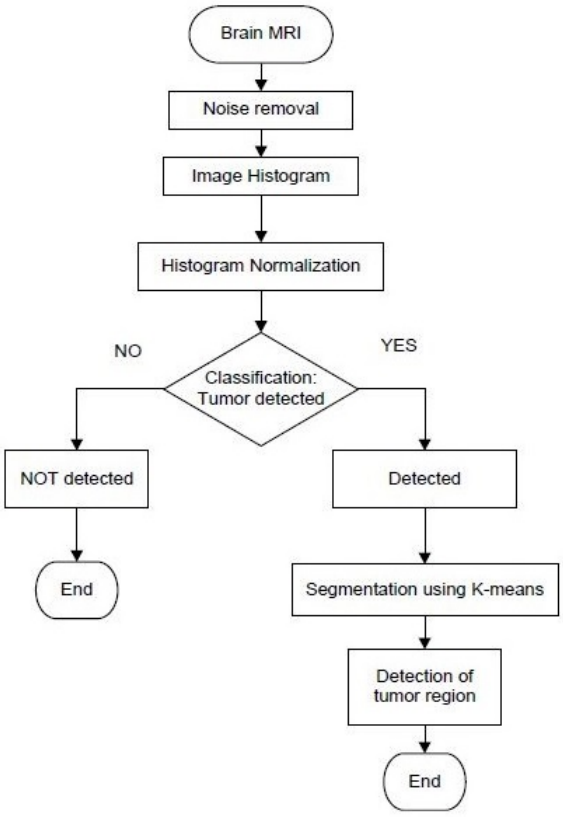

Figure 3: Flow Chart of Brain Paper

We then input regions around nodule candidates detected by the U-net into 3D CNNs to ultimately classify the CT scans as positive or negative for lung cancer. Preprocessing and segmentation referred to were threshold and watershed but thresholding was used in pipeline. After that pixel values are converted to HU(HOUSEFIELD UNIT) (TABLE) with value 400 thresholding . During training, our modified U-Net takes as input 256 x 256 2D CT slices, and labels are provided (256 x 256 mask where nodule pixels are 1, rest are 0). The model is trained to output images of shape 256 x 256 were each pixels of the output has a value between 0 and 1 indicating the probability the pixel belongs to a nodule using LUNA 16 Dataset for that. The trained U-Net is then applied to the segmented Kaggle CT scan slices to generate nodule candidates. And we would be able to say images with nodules as detected by U-Net are positive for lung cancer, and images without any nodules detected by U-Net are negative for lung cancer.

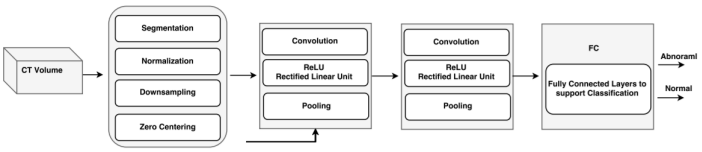

Figure 4: Lung similar system chart

Figure 4 describes the system overview of this paper [1]

• Beast Dense:

Mammographic density is known to be an important indicator of breast cancer risk. Classification of mammographic density is based on statistical features which have been investigated previously. Breast density, a measure of the extent of radio dense fibro glandular tissue in the breast, has the potential to be used as a predictor of breast cancer risk, it is a measure of how well tissue can be seen on mammogram [10]. Dense tissue in more than 50 percent of the breast could account for approximately one third of breast cancers[8]. In this paper [9], they described the development of an automatic breast tissue classification methodology, which can be summarized in a number of distinct steps: (1) pre-processing, (2) feature extraction, and (3) classification. Gray level thresholding and connected component labeling is used to eliminate the artifacts and pectoral muscles from the region of interest. Statistical features are extracted from this region which signify the important texture features of breast tissue. These features are fed to the support vector machine (SVM) classifier to classify it into any of the three class's namely fatty, glandular and dense tissue. The classifier accuracy obtained is 95.44 percent.

• Breast Cancer:

Computer-aided detection (CADe) and computer aided diagnosis (CADx) are emerging technologies to help radiologists interpret medical images. According to this paper [3] CADe can help radiologists avoid overlooking a cancer, while CADx can help radiologists decide whether a biopsy is warranted when reading a diagnostic mammogram. Even though there is much commonality in the techniques used in CADe and CADx algorithms, there are important differences in the input data and in the output of the algorithms. In particular, CADe outputs the location of potential cancers, while CADx outputs the likelihood that a known lesion is malignant. These differences affect the metrics used to evaluate their performance. Commercial CADe systems have been developed and clinical studies of CADe have indicated the ability to increase radiologists' sensitivity by approximately 10 percent with a comparable increase in the recall rate. Commercial CADx systems do not exist till date, but observer study results are very compelling. CADe and CADx schemes continue to evolve in terms of accuracy

and user interface. It is expected that CADe and eventually CADx will play an increasingly important role in breast imaging in the future. Also CAD works on Brain and Lungs.

Figure 5: CAD System View mentioned in [3]

2.3 User Characteristics

- Doctor:
  Should have the basic knowledge of using computer.
- Admin:
  Should have the basic knowledge of using computer.

2.4 User Problem Statement

- The classification result for images are difference from one doctor to another.Which make the patient confuse for which doctor has right diagnose.So we proposed a system to classify breast Dense automatically and also classify is it tumor or not. Doctor can't detect size and location of tumors accurate. So the system will detect the location and size of tumor automatically.

2.5 User Objectives

Doctor will be able to view classified images as tumor or non-tumor and the dense for breast. Doctor will be able to view the detected tumor region if found or the accurate dense of the breast which will save time and give higher accuracy that is not based on the experience of the doctor.

2.6 General Constrains

Choosing the correct image type (Breast/Brain/Lung) in the correct tab.

3 Functional Requirements

FID	FR1.
Name	Login.
Description	The doctor and admin should login to save the results. So it must have an account.
Input	Username and Password.
Output	Login successful / Login Failed.
Pre-condition	no data can access.
Post-condition	Login Successful without failure.
Action	It take the username and password from the user and check if he had a valid account or not and also the password is encrypted using MD5.
Dependencies	AddDoctor(FR8).
Criticality	10/10.

FID	FR2.
Name	UploadImage.
Description	The doctor should upload the patient image to start process of diagnose patient.
Input	Image id
Output	Image
Pre-condition	no image to diagnose.
Post-condition	image diagnoses.
Action	Image is Uploaded and started diagnose.
Dependencies	Login(FR1).
Criticality	10/10.

FID	FR3.
Name	AddPatient.
Description	Add Patient in the Patient list by the Doctor.
Input	Patient Info
Output	Data Added inserted in the Doctor Patient List
Pre-condition	This Data is not inserted in the database.
Post-condition	The Data Inserted Successfully.
Action	It take the Data of the Patient from the Doctor and inserted to the Database with the Doctor id.
Dependencies	Login(FR1).
Criticality	7/10.

FID	FR4.
Name	SearchPatient.
Description	Search Patient in the Patient list by the Doctor.
Input	Patient Name or Id
Output	Patient Record
Pre-condition	having the Name or the Id of the Patient.
Post-condition	Get all the Record of the Patient.
Action	Searching for patient's accoring to the name or id.
Dependencies	Login(FR1).
Criticality	7/10.

FID	FR5.
Name	DeletePatient.
Description	Delete Patient form the Patient list by the Doctor .
Input	Patient Record
Output	The Record Deleted
Pre-condition	The Record found in the Database.
Post-condition	The Record Deleted form the Database.
Action	It takes the record of the Patient and delete it from the Database.
Dependencies	SearchPatient(FR4).
Criticality	7/10.

FID	FR6.
Name	EditPatient
Description	Edit Patient in the Patient list by the Doctor.
Input	Record of the Patient
Output	Record updated
Pre-condition	The Record with the Old Data.
Post-condition	The new data is inserted successfully.
Action	It takes the id or Name of the Record and the New Item he want to update to and update it in the database.
Dependencies	SearchPatient(FR4).
Criticality	7/10.

FID	FR7.
Name	ListPatient
Description	List all the Patient for the Doctor.
Input	No input.
Output	All the Patients for the Specific Doctor.
Pre-condition	List of Patient is not available.
Post-condition	The Data of the Patients listed successfully.
Action	It take the Data of the Patient from the Doctor and inserted to the Database with the Doctor id.
Dependencies	Login(FR1).
Criticality	7/10.

FID	FR8.
Name	AddDoctor
Description	Add Doctor in the Doctor list of the admin.
Input	Doctor Info.
Output	Data Added inserted in the admin Doctor List
Pre-condition	The Data Inserted Successfully.
Post-condition	The Data Inserted Successfully.
Action	It take the Data of the Patient from the Doctor and inserted to the Database with the Doctor id.
Dependencies	Login(FR1).
Criticality	7/10.

FID	FR9.
Name	SearchDoctor
Description	Search Doctor in the Doctor list of the admin
Input	Doctor Name or Id
Output	Doctor Record
Pre-condition	having the Name or the Id of the Doctor.
Post-condition	Get all the Record of the Doctor.
Action	Give the Name or the Id to the function and it Search in the admin Doctor list and then return the Record the admin want.
Dependencies	Login(FR1).
Criticality	7/10.

FID	FR10.
Name	DeleteDoctor
Description	Delete Doctor form the Doctor list of the admin
Input	Doctor Record
Output	The Record Deleted
Pre-condition	The Record found in the Database.
Post-condition	The Record Deleted form the Database.
Action	It takes the record of the Doctor and delete it from the Database.
Dependencies	SearchDoctor(FR9).
Criticality	7/10.

FID	FR11.
Name	EditDoctor
Description	Edit Doctor in the Doctor list of the admin
Input	Record of the Doctor
Output	Record updated
Pre-condition	The Record with the Old Data.
Post-condition	The new data is inserted successfully.
Action	It takes the id or Name of the Record and the New Item he want to update to and update it in the database.
Dependencies	SearchDoctor(FR9).
Criticality	7/10.

FID	FR12.
Name	ListDoctor
Description	List all the Doctor for the admin.
Input	No input.
Output	All the Doctors for the Specific admin.
Pre-condition	List of Doctor is not available.
Post-condition	The Data of the Doctors listed successfully.
Action	It take the Data of the Doctor from the admin and inserted to the Database with the admin id
Dependencies	Login(FR1).
Criticality	7/10.

FID	FR13.
Name	ApplyThreshold
Description	Convert the gray scale image into binary image.
Input	Grayscale image and threshold value.
Output	Threshold binary image
Pre-condition	The image is gray scale.
Post-condition	The image is converted to binary image.
Action	It take the input image as gray scale and converts into binary image according to the threshold value
Dependencies	UploadImage(FR2).
Criticality	10/10.

FID	FR14.
Name	GetConnectedComponents.
Description	Get out the white labeled components together.
Input	Binary Image.
Output	Array with the connected components.
Pre-condition	Binary image with labels.
Post-condition	Binary image with labeled detection.
Action	It Takes a binary image and make some calculation to predict the white part in the image.
Dependencies	ApplyThreshold(FR13).
Criticality	10/10.

FID	FR15.
Name	GetBiggestConnectedComponents
Description	Get the biggest number of connected pixels in the image.
Input	Image path.
Output	Image in which the biggest connected component shown.
Pre-condition	Binary image with the connected components.
Post-condition	Return the image with only Breast area.
Action	It takes the Binary image with the connected components shown and return the highest connected component which is the breast area in the Image as a white pixels.
Dependencies	GetConnectedComponents(FR14).
Criticality	10/10.

FID	FR16.
Name	AddOriginalBreastImage
Description	It Puts the Original Breast image pixels on the Binary Image.
Input	Image specified the breast area as a white pixels in a binary image and the Original Image.
Output	Image with the breast Area as Grayscale part.
Pre-condition	Binary image specify the Breast Area Only.
Post-condition	The original breast image pixels are obtained.
Action	It Takes the both image and apply the breast part from the Original Image in the Binary Image.
Dependencies	GetBiggestConnectedComponents(FR15).
Criticality	10/10.

FID	FR17.
Name	CalculateMean
Description	It Calculates the Mean.
Input	Segmented Image.
Output	Image Mean.
Pre-condition	Image's mean is not calculated.
Post-condition	Image's mean is calculated.
Action	Takes the image and calculate the Average of the Pixels.
Dependencies	None.
Criticality	10/10.

FID	FR18.
Name	CalculateStandardDeviation
Description	It Calculates the Standard Deviation.
Input	Image.
Output	The standard deviation of the image.
Pre-condition	Standard deviation of the image is not calculated.
Post-condition	Standard deviation of the image is calculated.
Action	Calculation the total intensity in the image, calculating the average intensity of the image and then calculating the standard deviation.
Dependencies	Mean(FR17).
Criticality	10/10.

FID	FR19.
Name	CalculateSmoothness
Description	It Calculate the Smoothness value.
Input	Image.
Output	Image Smoothness value.
Pre-condition	The smoothness value is not known.
Post-condition	The smoothness value is known.
Action	Takes the standard deviation value and add one to the value , then make the total power 2 , after that divided 1 bye the total then for the final smoothness value make 1 minus the over all equation.
Dependencies	CalculateStandardDeviation(FR18).
Criticality	10/10.

FID	FR20.
Name	CalculateSkewness
Description	It Calculate the Smoothness value.
Input	Image.
Output	Image Skewness value.
Pre-condition	The Skewness value is not known.
Post-condition	The Skewness value is known.
Action	Takes the image and loop for each pixel in the image and calculate the total pixel value subtracted from mean and power 3 , then divided the total by total number of pixel multiply standard deviation value power 3.
Dependencies	CalculateStandardDeviation(FR18).
Criticality	10/10.

FID	FR21.
Name	CalculateKurtosis
Description	It Calculate the Kurtosis value.
Input	Image.
Output	Image Kurtosis value.
Pre-condition	The Kurtosis value is not known.
Post-condition	The Kurtosis value is known.
Action	Takes the image and loop for each pixel in the image and calculate the total pixel value subtracted from mean and power 4 , then divided the total by total number of pixel subtracted by 1 and multiply by standard deviation value power 4.
Dependencies	CalculateStandardDeviation(FR18), CalculateMean(FR17).
Criticality	10/10.

FID	FR22.
Name	CalculateUniformity
Description	It Calculate the Uniformity value.
Input	Image.
Output	Image Uniformity value.
Pre-condition	The Uniformity value is not known.
Post-condition	The Uniformity value is known.
Action	Takes the image and loop for each pixel value in the image and calculate total appearance for each value and store it in array, then get the probability for each pixel then tp calculate Uniformity value get the total of pixels probability power 2.
Dependencies	None.
Criticality	10/10.

FID	FR23.
Name	CalculateAverageHistogram
Description	It Calculates the Average Histogram.
Input	Image.
Output	Image average histogram value.
Pre-condition	The average histogram value is not calculated.
Post-condition	The average histogram value is calculated.
Action	Takes the image and calculate the Average Histogram of the Pixels.
Dependencies	None.
Criticality	10/10.

FID	FR24.
Name	CalculateModifiedStandardDeviation
Description	It Calculates the Modified Standard Deviation.
Input	Image.
Output	Image Modified Standard Deviation value.
Pre-condition	The Modified Standard Deviation value is not calculated.
Post-condition	The Modified Standard Deviation value is calculated.
Action	Take the image and calculate the Modified Standard Deviation of the Pixels.
Dependencies	CalculateMean(FR17).
Criticality	10/10.

FID	FR25.
Name	CalculateModifiedSkew
Description	It Calculates the Modified Skew.
Input	Image.
Output	Image Modified Skew value.
Pre-condition	The Modified Skew value is not calculated.
Post-condition	The Modified Skew value is calculated.
Action	It takes the image and calculate the Modified Skew of the Pixels.
Dependencies	CalculateMean(FR17), CalculateStandardDeviation(FR18).
Criticality	10/10.

FID	FR26.
Name	GetMaxMinNumberOfPixels
Description	It calculates the maximum graylevel and minimum graylevel and the number of pixels greater than 250.
Input	Image.
Output	The maximum graylevel, the minimum graylevel and the number of pixels greater than 250.
Pre-condition	the maximum graylevel and minimum graylevel and the number of pixels greater than 250 are not calculated.
Post-condition	the maximum graylevel and minimum graylevel and the number of pixels greater than 250 are calculated.
Action	Gets the max graylevel in the image and the minimum graylevel in the image and the counter of pixels greater than 250 graylevel.
Dependencies	UploadImage(FR2).
Criticality	10/10.

FID	FR27.
Name	CheckImage
Description	It checks if the counter of pixels obtained from the previous function equals to zero or not and accordingly it performs an operation.
Input	Image, Number of pixels greater than 250, min graylevel and max graylevel obtained from previous function.
Output	Image.
Pre-condition	Number of pixels greater than 250 is not known whether zero or not.
Post-condition	Number of pixels greater than 250 is known whether zero or not.
Action	Checks whether the Number of pixels greater than 250 obtained from the previous function is zero or not, if it is zero then it checks if every pixel greater than the min and smaller than the max obtained from previous function then it is set to 255.
Dependencies	GetMaxMinNumberOfPixels(FR26).
Criticality	9/10.

FID	FR28.
Name	ApplyMorphologicalOpen
Description	used predefined algorithm for morphological open to removes any artifacts in the image.
Input	Image and the kernel to be applied on the image.
Output	Image
Pre-condition	The image before applying morphological open.
Post-condition	The image after applying morphological open.
Action	It takes the threshold image and the kernel needs to be applied on the image and it removes the artifacts from the image.
Dependencies	ApplyThreshold(FR13).
Criticality	9/10.

FID	FR29.
Name	GetTumorAreaWithNoArtifacts
Description	It gets the tumor area after removing the artifacts.
Input	Image, the morphological open image.
Output	Image.
Pre-condition	The whole image with artifacts.
Post-condition	The image after applying morphological open.
Action	It reads the original grayscale image and the image after applying the morphological open on it and multiplies the two images together to remove the artifacts.
Dependencies	ApplyMorphologicalOpen(FR28).
Criticality	9/10.

FID	FR30.
Name	ApplyMedianFilter
Description	It applies the predefined median filter on the image after removing the artifacts.
Input	Image, The kernel of the filter.
Output	Image.
Pre-condition	The image before applying the median filter.
Post-condition	The image after applying the median filter.
Action	It applies the median filter on the image after removing the artifacts from it.
Dependencies	ApplySaltAndPepper(FR44).
Criticality	9/10.

FID	FR31.
Name	ApplyAverageFilter
Description	It applies the average filter on the image.
Input	Image.
Output	Image.
Pre-condition	The image before applying the average filter.
Post-condition	The image after applying the average filter.
Action	It applies the average filter on the image after applying the median filter by getting the average of all 3x3 kernel filter.
Dependencies	ApplyMedianFilter(FR30).
Criticality	9/10.

FID	FR32.
Name	ApplyGaussianFilter
Description	It applies the predefined Gaussian filter on the image.
Input	Image.
Output	Image.
Pre-condition	The image before applying the Gaussian filter.
Post-condition	The image after applying the Gaussian filter.
Action	It applies the gaussian filter on the image after applying the average filter.
Dependencies	ApplyAverageFilter(FR31).
Criticality	9/10.

FID	FR33.
Name	ApplyUnsharpFilter
Description	use predefined unsharped filter to enhances the edges of the image.
Input	Image , Image.
Output	Image.
Pre-condition	The image before applying the Gaussian filter.
Post-condition	The image after applying the Gaussian filter.
Action	It applies the gaussian filter on the image after applying the average filter.
Dependencies	ApplyGaussianFilter(FR33) , CheckImage(FR27).
Criticality	9/10.

FID	FR34.
Name	ApplyNormalizedHistogram
Description	It checks if the image is a tumor or non-tumor image.
Input	Image.
Output	Result of (tumor/non-tumor).
Pre-condition	Image is not classified as tumor or non-tumor.
Post-condition	Image is classified as tumor or non-tumor.
Action	It calculates the number of pixels in each graylevel and then calculates the probability of them by dividing each number of pixels of graylevel on the rows of the image multiplied with the columns of the image, the resulted probability is multiplied by 100 and summed to the beta. The resulted beta is compared to a calculated number (gamma) which is calculated by obtaining the sum of probabilities from 1 to 256 and dividing it by 256. If beta is greater than gamma then patient has tumor, if not then patient doesn't have tumor.
Dependencies	CheckImage(FR27).
Criticality	10/10.

FID	FR35.
Name	ApplyStructuringElement
Description	use predefined Structure element algorithm to removes the foreground pixels of the image.
Input	Image.
Output	Image.
Pre-condition	Image with foreground.
Post-condition	Image without foreground.
Action	It applies structuring element (rect), it erodes and dilates the image.
Dependencies	ApplyUnsharpFilter(FR33).
Criticality	10/10.

FID	FR36.
Name	ApplyKmeans
Description	use predefined KMean algorithm to Segments the tumor.
Input	Image.
Output	Image.
Pre-condition	Image before applying K-means segmentation.
Post-condition	Image with segmented tumor parts.
Action	It reshapes the image and changes it to float array and then apply clustering according to the number of K specified.
Dependencies	ApplyMorphologicalOpen(FR28).
Criticality	10/10.

FID	FR37.
Name	ApplyDilation
Description	use predefined dilation algorithm to increases the thickness of the pixels.
Input	Image, the kernel needed and the number of iterations.
Output	Image.
Pre-condition	Image before applying dilation.
Post-condition	Image after applying dilation.
Action	It dilates the image and increases the thickness of the pixels.
Dependencies	ApplyThreshold(FR13).
Criticality	8/10.

FID	FR38.
Name	ApplyEdgeDetection
Description	use predefined Edge detection algorithm by calling canny edge detection equation It highlights the edges of the tumor part.
Input	Image.
Output	Image.
Pre-condition	Image before applying edge detection.
Post-condition	Image after applying edge detection.
Action	It detects the edges of the segmented tumor part.
Dependencies	ApplyDilation(FR37).
Criticality	10/10.

FID	FR39.
Name	GetSlicesforpatient
Description	Can read all slices CT Scan Image of one patient using dicom read with specific path and sort them using their instance number.
Input	Dicom Path for one patient.
Output	Array of slices.
Pre-condition	Data for patient is available but separated and not sorted.
Post-condition	Sorted Slices according to their instance number.
Action	Slices are given with path for only one patient, slices are sorted with lambda key according to image position of patient from raw data. Here we 're sorting by the actual image position in the scan.
Dependencies	None.
Criticality	10/10.

FID	FR40.
Name	GetValuesOfHu
Description	use predefined house field unit to convert raw values of pixels into HU (house field unit).
Input	Array Of slices.
Output	Array of slices with house field unit calculated.
Pre-condition	Array of slices available but with the exact raw data format which is pixel data.
Post-condition	Array of slices according to house field unit.
Action	by getting the values of intercept and slope form (raw data) in order to multiply it with the given slices pixels and add sum it on intercept and cast it to obtain HU values such as -500 refers to lung.
Dependencies	GetSlicesforpatient(FR39).
Criticality	9/10.

FID	FR41.
Name	ResampleImage
Description	It Resamples slices for given patient as they may differ in size.
Input	House field units with given slices and resample number 1*1*1.
Output	New normalized pixel spacing.
Pre-condition	Images are all with pixel spacing different in each scan.
Post-condition	Images with new normalized pixel spacing to be [1,1,1].
Action	New spacing is calculated for every slice with resize factor used for example 1*1*1 in order to use it in conv3d neural network to be the same without worrying about zoom or slice thickness.
Dependencies	GetValuesOfHu(FR40).
Criticality	10/10.

FID	FR42.
Name	Plot3D
Description	Creates a mesh and place 3d object from specific slices
Input	Image, value of HU (threshold for example)
Output	3D shape of relative HU.
Pre-condition	2D slices only with Hu values
Post-condition	3D Shape of lung or Bone according to HU value .
Action	Creating a Transpose of shape x,y,z relative to shape 0,1,2 by creating an empty mesh and place plot size and fig size for mesh.
Dependencies	ResampleImage(FR41).
Criticality	9/10.

FID	FR43.
Name	SegementLungMask
Description	predefined functions to Segements lung parts only from slices.
Input	Slice of a patient.
Output	Mask of slices of patient.
Pre-condition	Slice image with whole shape of lung represented.
Post-condition	Only mask of lung represented with nodules.
Action	Image is Taken form user and converted into binary image then remove blobs from image connected such as outer part, then labeling image and remain 2 largest areas , erosion operation with disk 2 applied then exclude all with disk radius 10 , apply mask on original image.
Dependencies	GetValuesOfHu(FR40).
Criticality	10/10.

FID	FR44.
Name	ApplySaltAndPepper
Description	Function is used to salt and pepper image through noise black and white pixels.
Input	Image.
Output	Image.
Pre-condition	Normal image without salt and pepper.
Post-condition	Salt and peppered image.
Action	Function is used to apply salt and pepper on image.
Dependencies	ApplyThreshold(FR13).
Criticality	9/10.

FID	FR45.
Name	ApplyWatersheld
Description	Function is used to apply markers according to data of white pixels.
Input	Image.
Output	Image.
Pre-condition	Image not marked.
Post-condition	Image marked according to data with certain color for detection.
Action	Function is used to marker threshold image and takes only white pixels.
Dependencies	ApplyThreshold(FR13).
Criticality	8/10.

FID	FR46.
Name	ClearBorder
Description	Function is used to clear border of image.
Input	Image.
Output	Image.
Pre-condition	Normal Threshold image.
Post-condition	Threshold image without borders.
Action	It takes the binary image and convert it to cleared border image with no borders.
Dependencies	ApplyThreshold(FR13).
Criticality	9/10.

FID	FR47.
Name	AddImage
Description	This function is used to Add new image in the database.
Input	Image path.
Output	Image recorded in the database.
Pre-condition	The image is not found in the database records.
Post-condition	The new image is inserted in the database
Action	Doctor choose new image to add as a record in a specific patient .
Dependencies	Login(FR1).
Criticality	10/10.

FID	FR48.
Name	DeleteImage
Description	Helps the doctor to delete any image.
Input	Image record.
Output	Image deleted.
Pre-condition	This image have a record in the database.
Post-condition	No record for this image in the database
Action	when the doctor search for an image then he can delete it from the database.
Dependencies	SearchImage(FR47).
Criticality	6/10.

FID	FR49.
Name	EditImage
Description	Helps the doctor to edit any image record.
Input	Image record.
Output	Edited Image record.
Pre-condition	Image has an old record.
Post-condition	Image record edited
Action	when the doctor search for an image then he can edit the image record.
Dependencies	SearchImage(FR47).
Criticality	6/10.

FID	FR50.
Name	RemovePectoral
Description	This function is used to remove pectoral MLO from the Breast image.
Input	2 points.
Output	Breast Image without Pectoral MLO.
Pre-condition	Image with a pectoral not removed.
Post-condition	Image for Breast without the pectoral.
Action	doctor click with the mouse on the screen in 2 points in the image make a straight line that contain all pectoral line area to remove.
Dependencies	UploadImage(FR2).
Criticality	10/10.

FID	FR51.
Name	StartProcess
Description	Helps the doctor to choose which type of image will be uploaded to be diagnosed.
Input	None.
Output	Image Type.
Pre-condition	image type unknown.
Post-condition	Known Image type.
Action	When the doctor login will have to action to do addpatient or Startprocess which help him to use specific type of image will be uploaded.
Dependencies	Login(FR46).
Criticality	10/10.

FID	FR52.
Name	SVM
Description	use predefined SVM algorithm. this algorithm is used to train data and to return result for another data.
Input	Array of data and training Results and Image for classifying.
Output	Result.
Pre-condition	No trained data to use in predicting another data result.
Post-condition	Trained data with trained result and returned result for untrained data.
Action	This function takes all feature extraction values for every image as a trained data and also the trained result for this image as an input and then can classify any other data entered.
Dependencies	(FR17),(FR18),(FR19),(FR20),(FR21), (FR22),(FR23),(FR24),(FR25).
Criticality	10/10.

FID	FR53.
Name	Classify Cnn
Description	this function is used to train data and integrate with it with features to classify new inputs of images.
Input	training features , training labels , batch size, validation split , nb epoch.
Output	Epoch with Accuracy.
Pre-condition	Testing and training available but not calculated with each other .
Post-condition	Training and testing compared with each other and can accept new validation set.
Action	Training features are mentioned including functions for preprocess of images and reshape to 128 with np float16. Layers are constructed including Convlution 3d, Max Pooling , Average Pooling. After that compilation starts and accept layers with loss and metrics. Finally data is compared using fit to obtain accuracy.
Dependencies	(FR43)).
Criticality	10/10.

FID	FR54.
Name	Label
Description	this function is used to label the binary image , and split it into components.
Input	binary Image.
Output	Labeled Image.
Pre-condition	Image not labeled and it's considered to be as a one part .
Post-condition	image is splitted into components including the 2 lungs.
Action	label can take the binary image and start to iterate on pixels to find common values by giving different colors according to each component where each lung has a color .
Dependencies	(FR43)).
Criticality	10/10.

FID	FR55.
Name	GetDatatoPredict
Description	this function is used to get image from doctor for a specific patient to classify its dense.
Input	Image.
Output	Breast Dense as result.
Pre-condition	image not classified.
Post-condition	Classified image into one of the 3 categories if we use mias dataset or 4 categoires if we use DDSM dataset.
Action	Doctor upload image to be classified.
Dependencies	(FR54),(FR2).
Criticality	10/10.

4 Interface Requirement

4.1 User Interface

Our proposed system designed with a friendly UI. To be easily used by the user. On starting the application ask the user to choose one of the three categories (Breast, Lung, Brian). Then the user have to upload the patient's image. Then the application performs some operations on the image and output the classification result for this image. And the segmented tumor part if found.

4.1.1 GUI

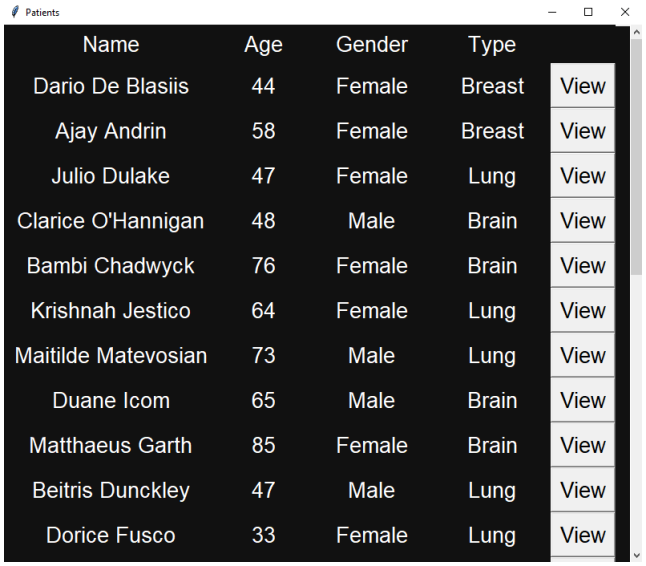

Figure 6: In this figure the doctor can see all patients Listed All in his account

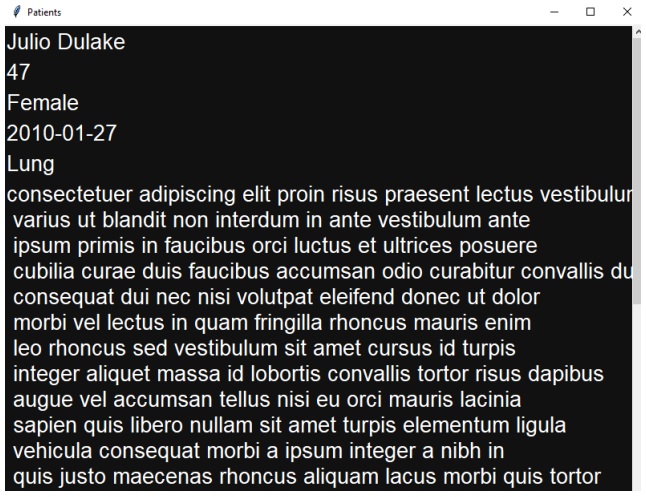

Figure 7: In this figure the doctor can see the date related to a specific patient

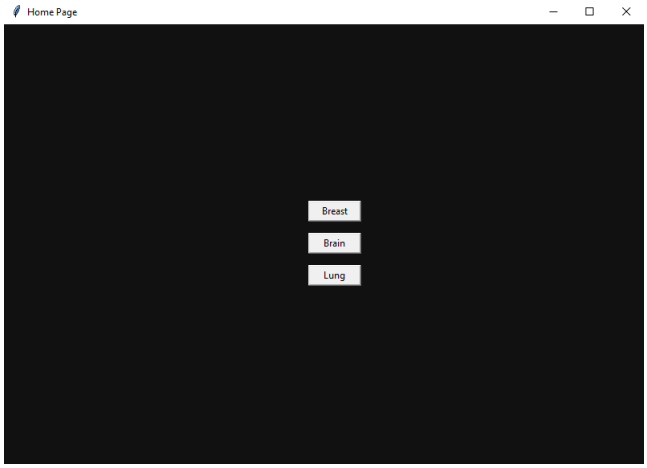

Figure 8: In this figure the user have to choose one of the three categories

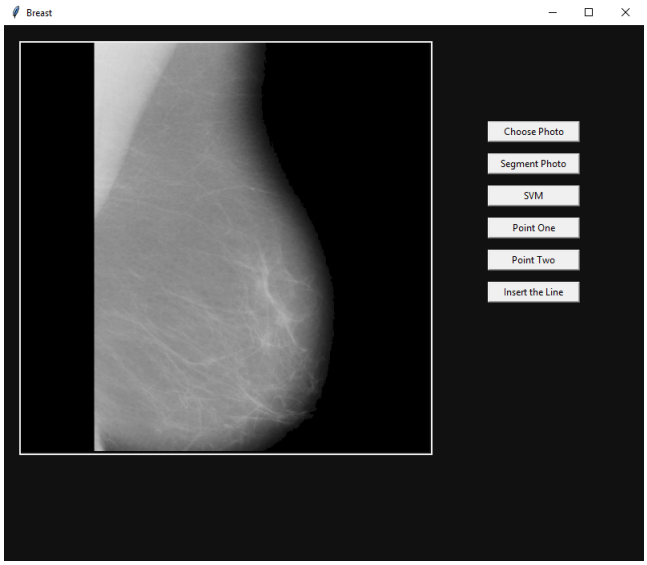

Figure 9: In this figure the result of choosing breast category. Then the user have to upload the patient image. Then use the app to pre-processing to remove the pectoral and to classify the breast dense type.

4.1.2 CLI

• Opencv Python installation:
- pip install numpy
- pip install scipy
• Github command lines
- git push origin master
- git merge "new-feature"

4.1.3 API

1st OpenCV: Is a library used for doing some operations on the image.

2nd SVM: Support vector machine is a new learning process influenced highly in computer processing power.Used in the application to classify the input image and output the result.
(FR17),(FR17), 3th Skimage: Is a Library for applying filters.

4th Scipy: Library for dealing with matplot, excel data(pandas) and applying filters.

5th Keras: Library for CNN classifier.

4.1.4 Diagnostic or ROM

Not Available

4.2 Hardware Interface

1st Magnetic Resonance Image "MRI": To get the scan of brain MRI image of patients.

2nd Digital Mammography: To get the scan of Breast Mammogram image of patients.

3rd Computed Tomography Scan: To get the scan of Lung CT scan image of patients.

4.3 Communication Interface

Not Available.

4.4 Software Interface

Not Available.

5 Performance Requirements

Image will be diagnosed and the result will appear to the doctor in about 30 seconds.

6 Design Constrains

This system needs to be user friendly to ease the process of achieving the required tasks by the doctors as a result of their lack of professional computer skills.

6.1 Hardware Limitations

This system is in need of powerful hardware to be able to deal with the huge datasets proposed in this system such as[6][7][2][5][**?**].

7 Non-Functional Requirements

7.1 Security

The result of a patient is a privileged data that shouldn't be accessed except by their doctor only. So it must be secured and not given a local access. Also the doctors' passwords should be secured.
FR Dependent on this: FR1, FR3, FR8

7.2 Reliability

This system provides a classified result which determines whether this patient has a cancer or not. So it must be made sure that this classification is accurate. Also this system yields a segmented image which determines the tumor size and location if found, so the doctor should be assured that this result is precise. Furthermore this system trains on a huge dataset which raises the accuracy of classification and segmentation. Also Reflects on handling exceptions which prevents system failure.

FR Dependent on this: FR36

7.3 Maintainability

The system should be easily maintained through implementing the MVC design pattern and using naming convention which ease the use of functions and understanding their purpose.

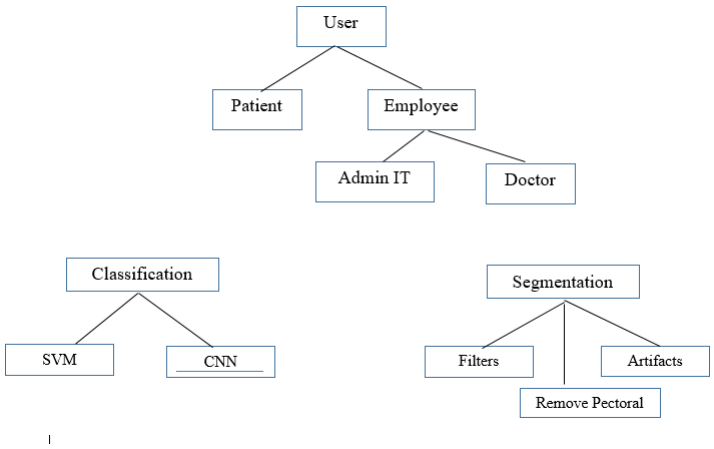

Figure 10: Inheritance Relations

8 Preliminary Object-Oriented Domain Analysis

8.1 Inheritance Relationships

8.2 Class descriptions

Class Name	User.
Super Class	None
Sub Class	Employee, Patient.
Purpose	Main class that contain all Attributes and Function for the subclasses .
Collaborations	Patient and Employee classes inherit from it.
Attributes	id: Int, Firstname: String, Lastname: String, Age: Int, Gender: String.
Operations	None

Class Name	Doctor.
Super Class	Employee.
Sub Class	None
Purpose	This class responsible for Control the Patient and to Start to diagnose the Image and have all controls for image.
Collaborations	inherit from Employee ,Aggregate with Patient and Aggregated by ControlLogin, ViewBreast, ViewListOfPatients, ViewHomePageChoices classes and Associated by AdminIT and ControlDocChoices Classs.
Attributes	Array of Patients.
Operations	ControlPatient(Add() ,Edit() ,Search() ,Delete() ,List()) ,StartProcess(), UploadImage(), RemovePectoral(), Obtain3DModel(), Segment(), GetResult(), GenerateReport() ,ImageControls(Edit,Add,Delete,Search).
Constrains	If the doctor doesn't have an account he can't access patients files.

Class Name	Employee.
Super Class	User
Sub Class	AdminIt, Doctor.
Purpose	Main class that contain all attributes and functions for subclasses.
Collaborations	Inherit from User and classes AdminIT, Doctor inherit from it.
Attributes	Id: int, Username: String, Password: String.
Operations	Login (String, String).

Class Name	Patient.
Super Class	User
Sub Class	None
Purpose	This class represents the data of each patient in the system.
Collaborations	: Inherit from User, Aggregated by ViewPatientInfo, Doctor, ReportValue Classes and associated by ControlListOfPatient class.
Attributes	Id: int, Weight: Float, Address: string, MobileNumber: string, Date: String, Description: String
Operations	None
Constrains	Only Admin and the patient's doctor can see the patient's information.

Class Name	AdminIT.
Super Class	Employee
Sub Class	None
Purpose	This class responsible for Control the Doctor.
Collaborations	: inherit from Employee.
Attributes	None
Operations	ControlDoctor(Add() ,Edit() ,Search() ,Delete() ,List())

Class Name	Type.
Super Class	None
Sub Class	None
Purpose	Have three Categories of cancer.
Collaborations	: Aggregated by classes Image, ReportConnection and ResultConnection.
Attributes	Id: int ,String: Type.
Operations	None

Class Name	ReportAttribute.
Super Class	None
Sub Class	None
Purpose	To collect All Attributes for the Report.
Collaborations	Aggregated by ReportConnection..
Attributes	int :Id, string: Attribute.
Operations	None

Class Name	ReportConnection.
Super Class	None
Sub Class	None
Purpose	To collect All Attributes for the Report to a specific type.
Collaborations	Aggregate ReportAttribute and Type classes, Aggregated by ReportValue Class
Attributes	int :Id,ReportAttribute: RepAtt, Type: typ.
Operations	None

Class Name	ReportValue.
Super Class	None
Sub Class	None
Purpose	Collect all Data for a specific Report Attribute for the Patient.
Collaborations	Aggregate ReportConnection and Patient classes.
Attributes	id:Int, RepConn: ReportConnection, Pat: Patient ,RepValue.
Operations	None

Class Name	ResulttAttribute.
Super Class	None
Sub Class	None
Purpose	To collect All Attributes for the Resultt.
Collaborations	Aggregate from ResultConnection.
Attributes	int :Id, string: Attribute.
Operations	None

Class Name	ResultConnection.
Super Class	None
Sub Class	None
Purpose	To collect All Attributes for the Report to a specific type.
Collaborations	Aggregate ResultAttribute and Type Classes, Aggregated by ResultValue.
Attributes	id: Int, Typ: Type, ResAtt: ResultAttributes.
Operations	None

Class Name	ResulttValue.
Super Class	None
Sub Class	None
Purpose	Collect all Data for a specific Report Attribute for the Patient.
Collaborations	Aggregate ResultConnection , Image Classes.
Attributes	: id: Int ,ResConn: ResultConnection ,Pat: Patient ,ResValue: String
Operations	None

Class Name	Image.
Super Class	None
Sub Class	None
Purpose	This class represents the image that the operations can be done on.
Collaborations	I: Aggregated by FeatureExtraction, Segmentation, ResultValue, Classification Classes and Aggregate Type Class.
Attributes	Id: int, PatientImage:Mat, ImageType:Type.
Operations	None
Constraints	Only Admin and the patient's doctor can see the patient's image.

Class Name	Feature Extraction.
Super Class	None
Sub Class	None
Purpose	This class represents the Features calculated from each image.
Collaborations	This class aggregate Image Class and aggregated by class Classification.
Attributes	Img: Image.
Operations	: Mean():float, Standard Deviation():float, Skewness():float, AverageHistogram (): float, ModifiedSkew (): float, ModifiedStandardDeviaton (): float, Kurtosis():float, Uniformity():float, Smoothness():float, NormalizedHistogram ():float.

Class Name	Segmentation.
Super Class	None
Sub Class	Filters, Artifacts and RemovePectoral
Purpose	This class represents the segmentation operations done on a specific image.
Collaborations	: This class Aggregate Image Class and Inherited by Filters, Artifacts and RemovePectoral Classes.
Attributes	Img: Image.
Operations	Morphological (): Mat, Median ():Mat.

Class Name	Filters.
Super Class	Segmentation
Sub Class	None
Purpose	This class represents the filters done on a specific image.
Collaborations	This Class is Inherit Segmentation class.
Attributes	None.
Operations Average (): Mat, Dilation (): Mat, Erosion (): Mat.	

Class Name	Artifacts.
Super Class	Segmentation
Sub Class	None
Purpose	This class represents the filters done to remove artifacts from a specific image.
Collaborations	This Class is inherit Class Segmentation and Aggregated by class ControlBreast.
Attributes	None.
Operations	Threshold (): Mat, GetConnectedComponents (): Mat, Structural Elements (): Mat, CompositeImages (): Mat, ClearBorders (): Mat.

Class Name	Remove Pectoral.
Super Class	Segmentation
Sub Class	None
Purpose	This Class for Remove Pectoral MLO from Breast Images.
Collaborations	This Class inherit class Segmentation and Aggregated by class ControlBreast.
Attributes	Point1: Point, Point2: Point..
Operations	Operation (): Point, GetSlop (): int, Structural GetUpPoint (): Int, GetDownPoint (): int, Direction (): String.

Class Name	Classification.
Super Class	None
Sub Class	SVM,CNN
Purpose	This class is a parent class to collect all common attributes from all child classes.
Collaborations	This class is inherited by SVM, CNN classes and Aggregate class Feature Extraction.
Attributes	Image: img
Operations	String: Classify()

Class Name	SVM.
Super Class	Classification
Sub Class	None
Purpose	This Class is used to classify with the SVM classifier (To train Data).
Collaborations	this Class inherit from classification class.
Attributes	PredictData: Array.
Operations	GetDataToPredict (): Void.

Class Name	CNN.
Super Class	Classification
Sub Class	None
Purpose	This Class is used to classify with the CNN classifier (To train Data).
Collaborations	inherit Classification as a parent class
Attributes	Float: Accuracy
Operations	None

Class Name	Control Breast.
Super Class	None.
Sub Class	None.
Purpose	This Class have all Controls for breast images to diagnose.
Collaborations	This class Aggregate Artifacts, Remove Pectoral classes and Associated by class View Breast.
Attributes	Art: Artifacts, RemPec: RemovePectoral.
Operations	Segment (): Mat, RemovePectoral(): Points.

Class Name	Control Doctor Choices.
Super Class	None.
Sub Class	None.
Purpose	This class is control all operations doctor can do.
Collaborations	This class is Associate class Doctor.
Attributes	TK: Tkinter.
Operations	ViewPatients (): Void, StartProcess (): Void.

Class Name	Control Home Page Choices.
Super Class	None.
Sub Class	None.
Purpose	This class to control and specify the Type of image will be uploaded.
Collaborations	: This class Aggregate classes ViewBreast, ViewBrain, ViewLung and Associate Class Doctor.
Attributes	VBreast: ViewBreast, VLung: ViewLung, VBrian: ViewBrain, TK: Tkinter.
Operations	BreastButton (): Void, LungButton (): Void, BrainButton (): Void.

Class Name	Control List of Patient.
Super Class	None.
Sub Class	None.
Purpose	This Class to list all patient for the login Doctor.
Collaborations	This class is Associate class Doctor.
Attributes	TK: Tkinter
Operations	ViewRecord (): Void.

Class Name	Control Login.
Super Class	None.
Sub Class	None.
Purpose	This class to make the doctor and Admin login.
Collaborations	This Class is Associate class ViewLogin and Aggregate Class Doctor.
Attributes	Tk: Tkinter, Doc: Doctor
Operations	Login (): String.

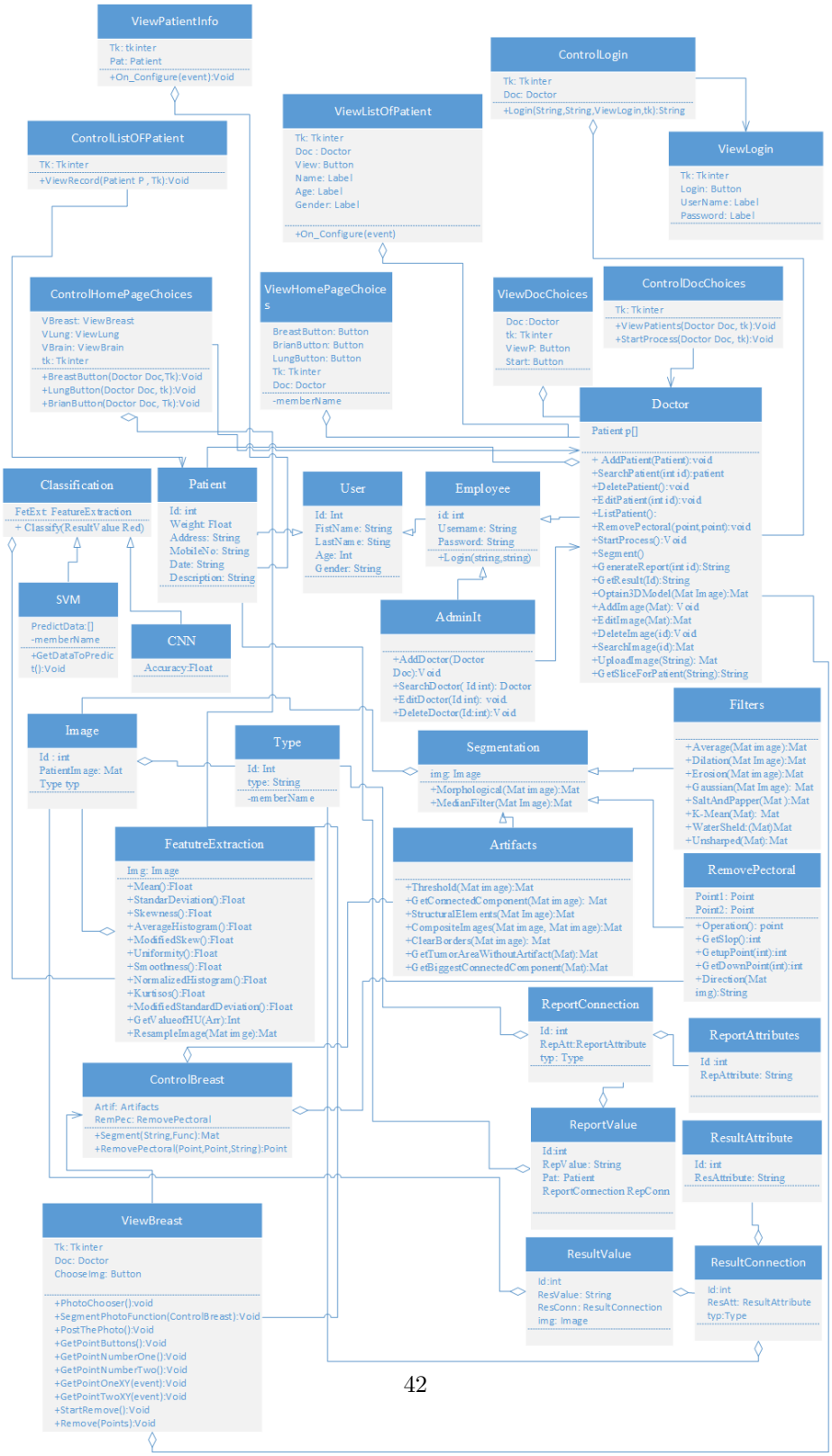

Figure 11: Class Diagram

9 Operational Scenarios

User manipulation:

The user included in this scenario is the admin. The admin has control over the system and can handle more functionality and assign privileges to doctor.

1) Add: Admin can add patient with data includes (Images, Info , status)

2) Edit: can edit in Images and edit information about patient and doctor's personal data

3) Delete record: Delete record can be (images, Patients data, doctor)

4) Searching : Can search for specific (patient or doctor)

5) list All : can list all doctors and patients who are assigned to him with their data including their status.

Doctor:

•Scenario 1:.

-Doctor can interact with segmentation system to segment an image.

-Segmentation System accepts Doctor request and start to apply different filters and artifacts.

-According to Type of Image(Brain/Lung/Breast), filters and artifacts are used.

•Scenario 2:

-Pre-processing System can calculate normalized histogram.

-Classification system takes the normalized histogram and starts to classify.

-After classification, results obtained from new validation set to be available for doctor to detect an Image.

•Scenario 3: -Admin It can add doctors to system including personal data and patients assigned to him.

-Admin It can search any doctor such as editing in his personal information, patients and can delete these records.

-After Admin It privilege, Doctor can access interface and upload images of different patients or edit/delete them or Generate report of different patients according to segmentation in Scenario 1.

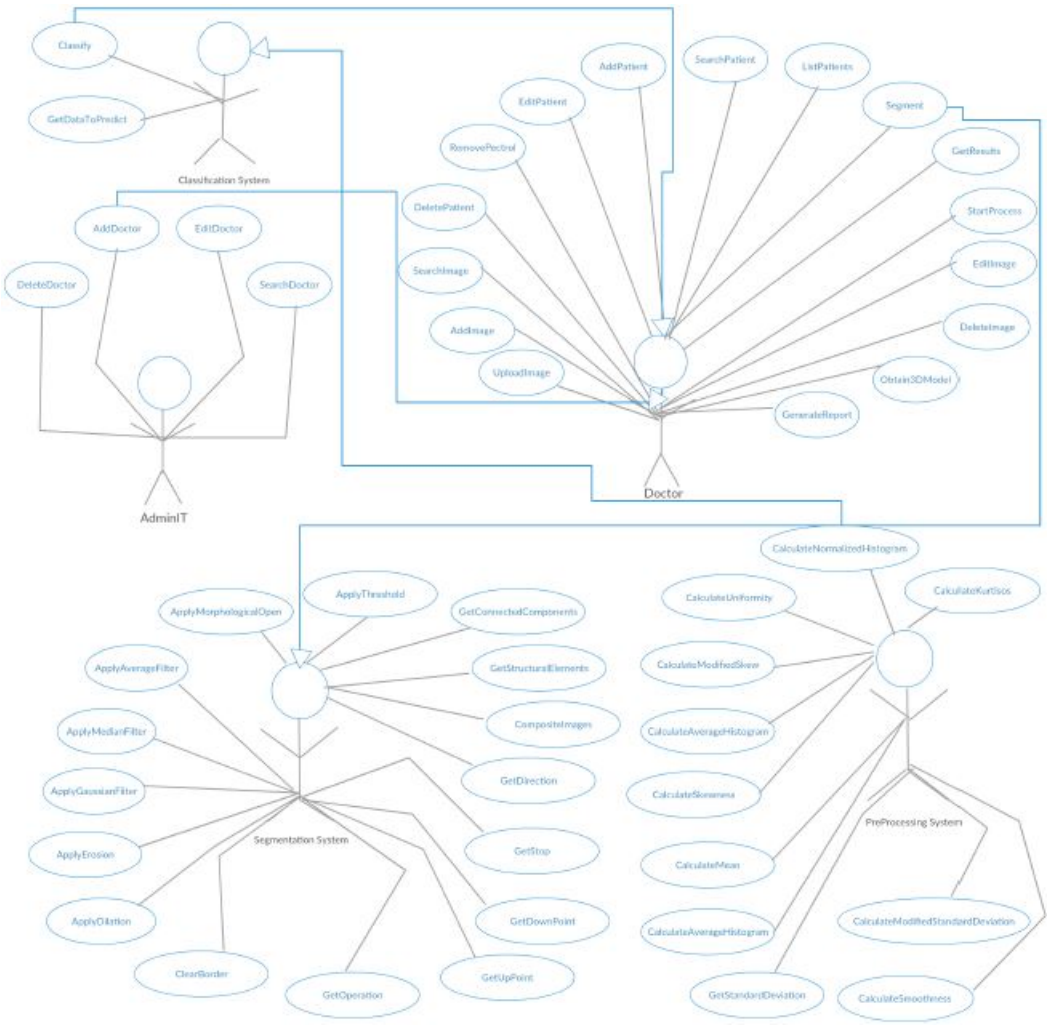

Figure 12: Use Case Diagram

10 Preliminary Schedule Adjusted

Phase	Start Date	End Date
Proposal Evaluation	26 Sep 2017	3 Oct 2017
SRS Evaluation	13 Nov 2017	15 Nov 2017
Prof. Jiro Tanaka	3 Dec 2017	11 Dec 2017
SDD Evaluation	17 Jan 2018	
Evaluation Implementation	30 March 2018	
Delivering 6 Pages Paper	12 April 2018	
Technical Evaluation	1st Week of May 2018	
Final Thesis	26 June 2018	

Figure 13: Time Plan

11 Preliminary Budget Adjusted

This system requires a Laptop budget within 12000 to 15000.

12 Appendices

SVM: Support Vector Machine.
CNN: Convolution Neural Network.
MRI: Magnetic resonance imaging.
CT Scan: Computed tomography Scan.
Pectoral MLO: Are the muscles that connect the front of the human chest with the bones of the upper arm and shoulder.

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