CHAPTER 2

LITERATURE SURVEY

A sample of reviews from the earlier literature is presented related to this work and discussed to highlight the importance of the proposed work. The focus is to list out the state of art research work using machine learning techniques in the field of computer aided diagnosis of cardiovascular diseases. This section is divided into three sub sections. In the first section imaging of CCA and associated diseases are discussed. In the later, literature related to various segmentation techniques and features related to CVDs are listed. Third section reviews the literature related to mathematical modeling, machine learning and CAD systems.

2.1 CCA DISEASES AND IMAGING TECHNIQUES

Advanced imaging techniques nowadays allow us to do early diagnosis, prevention and treatment of CVDs. This section will detail the role of imaging methods for the assessment of carotid artery pathology with an emphasis on the analysis, detection and characterization of carotid atherosclerosis.

A number of imaging techniques are used to detect atherosclerotic plaques, including angiography, intravascular ultrasound (IVUS), angioscopy, optical coherence tomography, magnetic resonance imaging, etc. These tools improve our understanding of the histopathological mechanism of atherosclerosis and help to develop the rapeutic strategies to prevent acute
coronary syndromes. An add-on technique to existing IVUS has been presented by Shi et al (2005) as an enhancement for vulnerable plaque characterization. It provides cross-sectional, tomographic perspectives of the vessel and permits real-time measurement of lumen area and plaque size.

Modified phased-tracking method for reduction of artifacts has been proposed by Hasegawa & Kanai (2006) to improve measurement of the small change in thickness of the arterial wall due to the heartbeat. In the case of a carotid artery of a healthy subject, there are only two dominant echoes from the lumen-intima and media-adventitia interfaces. In such a situation, only the change in the entire intima-media thickness can be estimated using ultrasound. The authors have modified this method in terms of the strategy for assignment of layers and the required thickness of an assigned layer to reduce such artifacts.

Baldewsing et al (2008) have proposed an inverse method for imaging the local elasticity of atherosclerotic coronary plaques. They have described an automated method for reconstructing the elasticity distribution of heterogeneous atherosclerotic coronary plaques, IVUS modulography. They have used the measured strain distribution or elastogram as the input to their method. Their approach is capable of estimating the total burden of dangerous soft thrombogenic materials. The combined approach used by them is IVUS modulography together with IVUS elastography. In conclusion, this approach has strong potential to become an all encompassing modality for detecting plaques, for accessing the information related to their rupture-proneness and for imaging their heterogeneous elastic material composition.

Saba et al (2012) have reviewed different methods for imaging of the carotid artery that analyse various alterations beyond simple luminal narrowing, including the morphology of atherosclerotic plaques, the arterial wall and the surrounding structures. Ultrasound echo color doppler is an
accurate and cost effective non-invasive screening tool. It is globally accepted as the standard imaging modality for first-line diagnosis of atherosclerosis of the carotid artery bifurcation. This high-resolution, non-invasive technique is readily available, rapidly applicable and can be performed at relatively low cost.

Zahnd et al (2012) have proposed a realistic multi-layer model of the common carotid artery to assess the accuracy of diverse computerized methods, despite the lack of ground truth inherent to in vivo ultrasound B-mode imaging. They have applied two computerized methods, namely a block-matching method and a segmentation method on their model to assess their accuracy. They have concluded from the results that their model can constitute a reliable method to quantity the accuracy of computerized algorithms. The results demonstrated a good precision of their methods compared to the reference and correspond to acceptable values in the clinical setting.

A high frame rate acquisition of RF echoes (3472 Hz) was achieved by Hasegawa & Kanai (2008) using parallel beam forming, which realizes the simultaneous imaging of the artery-wall strain and blood flow. In the estimation of strain, the global motion of the arterial wall was tracked based on the correlation between RF signals and the displacement distribution in the wall was then estimated using the phases of RF signals. Furthermore, the wall strain and blood flow of a carotid artery was successfully imaged in vivo. They have concluded that their proposed method would provide useful information for the diagnosis of atherosclerosis.

Smolen et al (2007) have developed a carotid artery stenosis stroke model. It is a micro simulation model with discrete even features to estimate stroke-free survival and mortality for a population of asymptomatic patients with substantial carotid artery stenosis receiving contemporary medical
therapy. They have validated the model by comparing model-predicted and actual stroke–free survival curves and stroke counts from a population of comparable patients. The validated model predicted stroke-free survival for a hypothetical medically managed arm of a recent single-arm carotid revascularization trial.

Optimal treatment of carotid artery disease has been given by Levy et al. (2008). They say that extracranial carotid artery disease accounts for approximately 25% of ischemic strokes. Although carotid endarterectomy (CEA) is the established gold standard for carotid revascularization, carotid artery angioplasty and stenting (CAS) is continually developing into a safer and more efficacious method of stroke prevention. They have concluded that clinicians must strive to perform well designed clinical trials that will continue to aid understanding and improve application of both endovascular and open techniques for extracranial carotid revascularization.

White (2010) has updated the current status of revascularizations therapies to reduce stroke in patients with extracranial carotid artery disease with focus on the most recent developments regarding the role of CAS. It no longer seems reasonable to quote best medical therapy outcomes. The optimal role of CAS or CEA for stroke prevention continues to be debated. The accumulated evidence from thousands of high-surgical-risk patients, for whom carotid revascularization was advised for stroke prevention, tells us that CAS is the procedure of choice in a suitable patient who can have the procedure performed in an experienced facility by an experienced interventionalist.

2.2 SEGMENTATION AND FEATURE EXTRACTION

Segmentation is often an important step in image analysis. Segmentation of deformable structures is a common processing problem in
medical imaging. For example, carotid atherosclerotic plaque is estimated from US images by segmenting and measuring lumen diameter and intima–media layer thickness. This work is generally manually performed. However, due to the tedious nature of manual tracing, many research groups have worked on developing semi-automatic and automatic segmentation methods.

The drawbacks of manual ultrasonic measurements of human carotid artery walls are interobserver variability and inefficiency. Liang et al (2000) have proposed an automated method which reduces these problems. They have applied multiscale dynamic programming to detect the boundaries. Human factors in the determination of boundaries are reduced. They have incorporated the human knowledge of the artery image in the system to make the system capable in processing images of different quality. Evaluation of the system shows reduced interobserver variability as well as overall analysis time.

The main symptom of atherosclerosis is the carotid intima layer thickening in proximity to the endothelial lumen surface. This thickening can be also confined to a short artery segment, and in this case, it is called plaque. It can be detected and evaluated by measuring intima-media thickness. Liguori et al (2001) have presented an automatic system for the measurement of carotid IMT that is based on the digital processing of ultrasound images. Their findings show that the automation of the detection and measurement process grants high repeatability and accuracy in IMT measurements independently of the human technician expertise.

Xiao et al (2002) have suggested that B-mode ultrasound imaging is one of the most frequently used diagnostic tools for a range of clinical applications. Because images are available in real time, there is a low health risk to the patient and the cost of the scan is low relative to the cost of other imaging modalities. They have evaluated a method for simultaneous
attenuation distortion correction and image region segmentation of video-intensity US images. The method is novel in that it uses a combination of maximum a posteriori and markov random field methods to eliminate the US image distortions and label image regions based on their correct intensity statistics.

A fully automatic method for luminal contour segmentation in intracoronary ultrasound imaging has been developed by Brusseau et al (2004). Its principle is based on a contour with a prior properties that evolves according to the statistics of the ultrasound texture brightness, which is generally Rayleigh distributed. They have compared the automatic contours to those manually drawn by two physicians in terms of mean absolute difference. The results demonstrate that the error between automatic contours and the average of manual ones is of small amplitude and only very slightly higher than the interexpert error.

Plissiti et al (2004) have developed an automated method, which can be used for a sequence of IVUS frames to detect lumen and media-adventitia borders. They have used deformable models and optimization of the energy function using a hopfield neural network. Their method is advantageous compared with other techniques since they have addressed the problems related to calcified regions, image artifacts and noise. They have validated their method by comparing its result with the manual estimation of borders. Validation results prove that their method is one of the most efficient and accurate methods for IVUS segmentation.

Yan & Kassim (2006) have presented a method for segmentation of medical images by extracting organ contours, using minimal path deformable models incorporated with statistical shape priors. They have considered boundaries of structures as minimal paths. An intelligent “worm” algorithm for segmentation is used to evaluate the paths and finally find the minimal
path. Prior shape knowledge has been incorporated into the segmentation to achieve more robust segmentation. The proposed segmentation framework has overcome the shortcomings of existing deformable model and has been successfully applied for segmenting various medical images.

Delsanto et al (2007) have developed a Completely User-independent layers extraction (CULEX) algorithm for the segmentation of the distal border of the CCA. The segmentation accuracy is tested by comparing manually traced contours to the ones automatically produced by CULEX. Results revealed that the technique might be proficiently used in clinical practice to accurately segment the far wall at CCA in B-mode ultrasound scans. The average segmentation error is lower than 1 pixel. From a clinical point of view, the algorithm traces the boundaries of the intima and media layers. However, the reliability of the computer-generated boundaries in presence of strong blood backscattering is low due to poor image quality.

An integrated system for the segmentation of atherosclerotic plaque has been evaluated by Loizou et al (2007) in ultrasound imaging of the carotid artery based on normalization, speckle reduction filtering. They have applied four different snakes segmentation methods namely Williams and Shah, Balloon, Lai and Chin, and the gradient vector flow snake. The receiver operating characteristics (ROC) analysis has been used to assess the specificity and sensitivity of the four segmentation methods. They have obtained satisfactory results with the best performance obtained by the Lai and Chin snakes segmentation method.

Nascimento & Marques (2008) have addressed object tracking in ultrasound images using a robust multiple model tracker. They have applied a robust algorithm which is able to deal with multiple dynamics and invalid observation at the same time for tracking the boundary of the left ventricle in sequences of ultrasound images. The evolution of the shape and motion
parameters is described by a bank of switched dynamic system which can represent complex motion and shape dynamics. They have observed that the proposed method efficiently estimates the ventricle contour in ultrasound images, corrupted by speckle noise and outliers, without losing track.

Destrempes et al (2009) have done a work to perform segmentation of the IMT of carotid arteries in view of computing various dynamical properties of that tissue, such as the elasticity distribution. They have used a mixture of three Nakagami distributions to model the echogenicity of the region of interest comprising the intima-media layers, the lumen and the adventitia in the ultrasound B-mode image. This method is well suited to a semi-automatic context that requires minimal manual initialization. They have suggested that the semi-automatic segmentations obtained by the proposed method are within the variability of the manual segmentations of two experts in the case of disease-free carotids.

A novel method has been proposed by Vukadinovic et al (2010) for carotid artery vessel wall segmentation in the computed tomography angiography data. The first step of the method is level-set based lumen segmentation, initialized with three seed points, one in the common carotid artery, one in the internal carotid artery and one in the external carotid artery. In the second step, calcium regions located within the vessel wall are automatically detected and classified using multiple features in a Gentle-Boost framework. In the third step, pixels outside the lumen area are classified as vessel wall or background, using the same Gentle-Boost framework with a different set of image features.

A review of several plaque-image analysis methods has been done by Kyriacou et al (2010). They have analyzed clinical methods for image acquisition, described methods for image segmentation and denoising, and provided an overview of the several texture feature extraction and
classification methods that have been applied for plaque-image analysis over the past years. They concluded that the majority of plaque image analysis is focused on the development of 2D ultrasound systems. Extraction of 3D shape and structure information can be used for the understanding of carotid plaque morphology.

Molinari et al (2010a) proposed two groups of segmentation strategies. Group-1 contains techniques for the computer-aided IMT measurement in an integrated framework and the group-2 has completely user-independent and complete automation techniques for CA wall segmentation. The algorithms of group-1 are mainly devoted to the IMT measurement under the supervision of a human operator. On the overall, group-1 offer better IMT measurement performances than those of group-2. This is due to the fact that, under human supervision, IMT is usually measured in a portion of the image where noise is low and there are no artifacts. They conclude that the interaction with the user is certainly beneficial in terms of measurement performance.

Destrempes et al (2011) have done segmentation of atherosclerotic plaques in view of evaluating their burden and to provide boundaries for computing properties such as the plaque deformation and elasticity distribution. Prediction of the segmentation plaque, based on motion field estimates is included into the prior of a Bayesian model in the form of a spatiotemporal cohesion constraint. The proposed method requires manual segmentation of the plaque in the first frame of the video sequence. Their tests indicate that the semiautomatic segmentations of plaques located at internal proximal carotid arteries obtained by this method compare favourably to the state-of-the-art segmentation methods.

Several approaches have been reported in the literature for automated and semi automated border detection from ultrasound images.
Belaid et al (2011) have used level set propagation to capture the left ventricle boundaries. The proposed approach uses a new speed term based on local phase and local orientation derived from the monogenic signal, which makes the algorithm robust to attenuation artifact. A key advantage of this approach is that it is more robust to intensity in homogeneities. Their results on synthetic and natural data show that the proposed method can robustly handle noise, and capture well the low contrast boundaries.

A fully automated computer based method based on ultrasound image processing and a frequency domain implementation of active contours has been proposed by Bastida-Jumilla et al (2013) with the aim to reduce the inter-observer variability and the subjectivity of the IMT measurement. The proposed method has overcome previous methods based on snakes because it implements the contours in a frequency domain, which provide significant computational savings. The shape function used in this work is a cubic B-spline. This shape form has been chosen for its good performance and because it produces smooth edges.

Association of coronary heart disease (CHD) with common carotid artery near and far wall IMT are investigated by Polak et al (2015). They have observed that far wall CCA IMT measurements are superior to combining near wall and far wall IMT measurements for the prediction of CHD events. Their findings suggest that mean far wall IMT of the CCA is the best predictor of events, whereas combined far and near wall IMT measurements might better track changes in risk factors. They have concluded that far wall IMT is a significant independent predictor of hard cardiovascular events, an outcome that included stroke as well as events related to CHD.

Wilhjelm et al (1998) have done a quantitative comparison of subjective classification of the ultrasound images obtained during scanning before operation, first and second order statistical features extracted from the
regions of the plaque in still ultrasound images from three orthogonal scan planes and finally a histological analysis of the surgically removed plaque. They have concluded that the combined effect of the large number of uncontrolled factors that may influence the gray level of the plaque regions in clinical B mode images, the corresponding large inter-patient variation and the uncertainty in the histological analysis, seem to explain the only moderate between first and second order image features and plaque constituents.

A theoretical study on vulnerable atherosclerotic plaque reconstruction has been done by Le Floc’h et al (2009). The study is based on segmentation driven optimization procedure using strain measurements. Precise knowledge of the mechanical properties of plaque components would allow a precise evaluation of good biomechanical predictor of plaque rupture. This theoretical study has been designed to determine the modulogram of complex atherosclerotic plaques by developing an original preconditioning step for the optimization process, and a new approach combining a dynamic watershed segmentation method with the optimization procedure to extract the morphology and Young’s modulus of each plaque component.

Loizou et al (2009) have done a study to investigate an automated method for segmenting the intima and media layer and measurement of IMT. The objective of this study was to develop and evaluate a snakes segmentation system enabling the automated segmentation and measurement of the IMT in ultrasound images of CCA and investigate this variability with age groups. They have observed that the gray scale median and other texture features extracted from the different layers of CCA could have prognostic impact for the assessment of cardiovascular risk. They have suggested to relate the risk factors like smoking, blood pressure, inflammation markers and cholesterol to the IMT as they have correlation to the traditional carotid IMT.
A completely automatic layer extraction based on integrated approach also has been described by Molinari et al (2010b) for the segmentation and IMT measurement of the carotid wall in ultrasound images. Increase in common carotid arterial stiffness is a risk factor for cardio and cerebrovascular diseases. It has been reported that resistance training may increase or decrease the arterial stiffness. Shen et al (2014) have investigated acute impacts of upper and/or lower limb resistance training on common carotid arterial stiffness and local hemodynamics.

2.3 CAD AND MATHEMATICAL MODELING

Interpretation of medical images is usually performed by radiologists. It is often limited due to the non-systematic search patterns of humans, the presence of structure noise in the image, and the presentation of complex disease states requiring the integration of vast amount of image data and clinical information. Computerized analysis, using advanced image processing tools, is expected to improve medical image interpretation. Hence, Computer aided diagnosis through machine learning techniques may serve as a better tool in detecting, assessing disease severity and making diagnostic decisions.

A computer-aided system that will facilitate the characterization of carotid plaques has been developed by Christodoulou et al (2008) for the identification of individuals with asymptomatic carotid stenosis at the risk of stroke. They have extracted texture features and shape parameters from the segmented plaque images for classification. Texture contains important information that is used by humans for the interpretation and the analysis of many types of images. Texture refers to the spatial inter relationships and arrangement of the basic elements of an image. They have concluded that it is possible to identify a group of patients at risk of stroke based on texture features extracted from ultrasound images of carotid plaques.
Joo et al (2004) have developed a CAD algorithm that identifies breast nodule malignancy using multiple ultrasound features and artificial neural network classifier. They have suggested that ultrasound CAD system can give a second opinion to physicians for tumor characterization and can improve physician performance in the task of differentiating malignant from benign breast lesions on ultrasound images. However the developed CAD algorithm has the potential to increase the specificity of classification of breast lesions.

A segmentation method of the carotid far wall based on machine learning has been proposed by Menchon-Lara & Sancho-Gomez (2014) in order to measure the Intima-Media thickness in a reliable and automatic way. They have used Radial Basic function networks to perform the classification of the pixels in order to find the IMT contours. Intensity values from a square neighborhood centered on the pixel to be classified were used as input patterns. The learning process of the network and the selection of the optimal number of radial units were solved by means of the optimally pruned-Extreme learning machine.

Opbroek et al (2015) presented a transfer learning approach to image segmentation, which enables supervised segmentation of images acquired with different imaging protocols. They have presented four transfer classifiers that can train a classification scheme with only a small amount of representative training data, in addition to a larger amount of other training data with slightly different characteristics. The experiments showed that when there is only a small amount of representative training data available, transfer learning can greatly outperform common supervised-learning approaches minimizing classification errors by up to 60%. The authors believe that transfer learning is a promising approach to biomedical image analysis.
Gastounioti et al (2015) have investigated the unexplored potential of kinetic features in assisting the diagnostic decision for carotid atherosclerosis in the framework of a computer-aided diagnosis tool. The CAD schemes were benchmarked interns of their ability to discriminate between symptomatic and asymptomatic patients and the combination of the fisher discriminant ratio, as a feature-selezione strategy, and support vector machines, in the classification module was revealed as the optimal motion-based CAD tool. The motion-based CAD performance was thoroughly evaluated using multiple cross-validation techniques and it was also found to be superior to texture-based characterization of carotid atherosclerotic plaques.

Stoitsis et al (2006) have described a modular software system ANALYSIS which is designed to assist interpretation of medical images. This software allows texture and motion estimation of selected regions of interest. An important feature of ANALYSIS is the possibility for online telecollaboration between healthcare professionals under a secure framework. ANALYSIS was applied to B-mode ultrasound images of the carotid artery for performing various diagnostic tasks like segmentation, extraction of features, motion analysis and clustering of features. They have concluded that ANALYSIS can provide a useful platform for computerized analysis of medical images and support of diagnosis.

In recent years, remarkable progress has been made in simulating blood flow in realistic anatomical models constructed from medical imaging data. Quantification of blood flow and pressure fields by mathematical model is important to understand the response of the cardiovascular system to biomechanical forces. Information on the mechanics of blood flow is required to predict the potential for plaque formation and the likelihood of plaque...
disruption. With the introduction of CAD, a wide area of possible telematics applications for cardio vascular disease can be identified.

Lee et al (2004) have developed an ultrasound image-based computer model of a common carotid artery with a plaque. They have used ultrasound scans from a CCA in a patient with an early atherosclerotic plaque forming a mild asymmetrical stenosis. They have reconstructed the 3D vascular geometry of the diseased arterial segment from a series of a 2D cross-sectional images and developed computational meshes for the flow and wall domains. Although their model involves a number of assumptions, results obtained from this study have provided considerable insight into the flow and wall behavior in mildly stenosed arteries under physiological conditions.

Vignon-Clemental et al (2006) have described the three dimensional finite element modeling of the blood flow and pressure in the major arteries. They have derived outflow boundary conditions for any downstream where an explicit relationship of pressure as a function of flow rate or velocities can be obtained at the coupling interface. They have developed this method in the context of a stabilized, semi discrete finite element method. In the development of the circulatory system in normal subjects and congenital heart disease patients, flow modulated diameter and pressure controls wall thickness. They have demonstrated this method on a straight, cylindrical blood vessel, a bifurcation model with a stenosis on one side, and a subject specific model of the human abdominal aorta.

It has been clearly stated in the literature by Agarwal et al (2008) that the detailed knowledge of the flow patterns in arteries and especially in bifurcation is of high clinical interest. A bifurcation of clinical interest is the carotid artery bifurcation where the CCA divides into external and the internal carotid arteries. This latter artery generally shows a widening its proximal part.
called carotid sinus. Atherosclerotic lesions are often located proximally in the sinus on the non divider wall. The regions of high shear are found at the divider wall of the bifurcation while the regions of low shear and recirculation occur at the non divider wall, especially in carotid sinus. Thus the detailed knowledge of flow behavior is necessary. The authors have developed mathematical modeling of pulsatile flow in carotid artery bifurcation.

Ley & Deshpande (2009) have used two mathematical models of heat transfer to show the relationship between blood flow and changes in fingertip temperature experienced during vascular occlusion and reperfusion. Their models intend to increase the interest of the clinical community in the thermal study of vascular reactivity compared to other techniques that focus on the analysis of flow.

Kumar Gupta (2011) has also analyzed blood blow through carotid artery to develop a mathematical model. It has been suggested that the outcomes of this investigation may be useful for the treatment of hypertension patients through magnetic therapy. Zhang et al (2012) have analyzed the flow patterns and wall shear stress distribution in human internal carotid arteries and investigated the effect on the risk for stenosis.

One of the most important steps for the classification task is extracting suitable features capable of distinguishing between classes. Methods using statistical features, morphological features and shape features are limited in that they analyze the image in a single scale. In recent years, researchers have devised methods based on multi-scale representation for image processing applications. Multiwavelet analysis is one way to generate such representation.

Jafari-Khouzani & Soltanian-Zadeh (2003) have developed a computerized method for grading the pathological images of prostate biopsy
samples using multiwavelets. They have demonstrated that energy and entropy features derived from multiwavelet transform result in accurate classification. They have shown that the multiwavelet basis significantly affects the classification results. The second value of decomposition has less sensitivity to noise compared with the first level. They have concluded that the problem with the use of multiwavelets for feature extraction is the large number of features produced. Coarser resolutions may have important information, but with higher decomposition levels, the number of sub matrices grows rapidly. The dimension of the feature space can be reduced by using feature selection methods.

Soltanian-Zadeh & Rafiee-Red (2004) have presented an evaluation and comparison of the performance of four different texture and shape feature extraction methods for classification of benign and malignant microcalcifications in mammograms. They have used multi wavelets as one of the methods. The multi wavelet method outperformed the other three methods. The method for feature extraction is based on decomposing the images using multiwavelets and calculating the entropy and energy of each sub bands. They have used GHM multi wavelet. GHM scaling functions are symmetric about their centers. This allows symmetric extension when dealing with boundaries. This prevents discontinuity at the boundaries and therefore a loss of information in these points would be prevented.

A multiresolution approach is suggested for texture classification of atherosclerotic tissue from B-mode ultrasound in the literature (Tsiaparas et al 2011). This study demonstrated that wavelet-based texture analysis may be promising for characterizing atheromatous tissue. The authors have investigated four decomposition schemes, namely the discrete wavelet transform, the stationary wavelet transform, wavelet packets and Gaber transform in terms of their ability to discriminate between symptomatic and
asymptomatic cases. The mean and standard deviation of the detail sub images produced for each decomposition scheme were used as texture features for the classifiers using support Vector machines and probabilistic neural networks. An interesting find was that the dominant texture features may be affected by plaque strains.

A comprehensive method for segmenting the retinal vasculature in fundus camera images using multi wavelets has been proposed by Wang et al (2013). This method does not require preprocessing and training. Therefore it can be used directly on different image sets. They have used matched filtering with multi wavelet kernels to enhance the vessels. They have observed that the wavelet functions respond to vessels and clutters respectively, thus allowing them to identify and eliminate a good percentage of erroneous candidates.

From the exhaustive literature survey, it is clearly understood that the structure and functional behavior of CCA changes due to diabetes, hypertension, and atherosclerosis. Atherosclerosis is the major risk factor for cardiovascular disease, congestive heart failure and stroke. Especially the IMT, which is evaluated by the segmentation of intima and media layers of CCA, is proposed as a powerful and independent risk factor for atherosclerosis and hence cardiovascular disease. Knowledge of the blood flow and pressure in normal and in diseased arteries will be useful in the study of cardiovascular disease and stroke.

It is shown that the elastic and mechanical properties of arteries will be useful in the study of cardiovascular disease. Most of the segmentation algorithms discussed try to extract only the contours and edges in the image. Perfect boundary extraction is done only in few papers. It is observed that multi wavelets have many useful properties that offer a great potential for applying them to image processing applications. Much of the above
mentioned research works are done in spatial domain and very less work has been carried out in transform domain using multiwavelets. In the proposed work both spatial and transform domain features are used for machine learning.

The studies have shown that features extracted from ultrasound images can be useful in the diagnosis of atherosclerosis and enable decision making. Atherosclerosis is estimated by parameters like elasticity, stiffness, lumen diameter, distension and IMT which can be used as an indicator of cardiovascular disease. Experienced radiologists are required to measure these parameters from the ultrasound images for the correct diagnosis. If a system could be automated to measure these parameters and thereby diagnose the CVDs, no doubt that this would be a milestone in the efforts taken to prevent cardiovascular disease. This work is a step taken towards the development of classifiers for the diagnosis of CCA abnormalities from longitudinal ultrasound B-mode images using machine learning approaches.

In this proposed work CCA images are analysed in both spatial domain and Transform domain. In the spatial domain, segmentation of near-far wall, lumen and intima-media regions of CCA is done. After the segmentation, Lumen Diameter and IMT are measured for both normal and abnormal images. Then these features are used for developing classifiers for the classification of normal and abnormal arteries. In the transform domain CCA images are analysed using multiwavelets. Decomposition of subbands is done by using HM & GHM multiwavelets. For each band, energy is computed. Then these subband energies are used for developing classifiers for the diagnosis of abnormal arteries.