European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 8, Issue 3, 2021

Feasibility study of diabetic disease using segmentation technique

Gayatri Joshi,
Asst.Professor,ACS college of Engineering
Email ID:gayitrijoshi@gmail.com

Dr.Punal M Arabi,
Professor, ACS college of Engineering
Email ID:arabi.punal@gmail.com

Abstract

Diabetes is a lifelong and long-term disease, which occurs when the pancreas does not produce enough insulin or the body produces insulin but it is not used properly. This leads to an increased concentration of glucose in the blood (hyperglycaemia).Around the globe many lives are frequently affecting through Diabetes. If Diabetes is not treated properly it will lead to lot of complications. If there is excess of glucose in the blood it causes vascular disease, this excess glucose damages the blood vessels also. In Type 1 diabetes body don't process enough insulin.Type-2 diabetes consists of array of dysfunction characterised by hyperglycaemia or it resists insulin. Hyperglycaemia induces large number of alterations which can result in atherosclerotic legion formation in the arteries and which will lead related conditions of diabetic vasculopathies. Type2 diabetic subjects are particularly at risk for vascular injury; adjunct in many of the subjects, cholesterol and triglyceride levels reach dangerously high levels and accumulate in the lumen of the subject's vascular system.

All over the world about 463 million people are suffering from diabetes according to international diabetes federation. In that 77 million people are belongs to India. 8.7% diabetic population estimated in India in the age group of 20 and 70 years during the year 2020. There are three different types of diabetes namely,Type1,Type2,Gestational diabetes. Major risk factors for diabetes are over weight, obesity. Common signs of diabetes are often urination ,feeling hungry,feeling thirsty,blurry vision,weight loss,numbness in hands,feet.Diabetes is diagnosed by glycated haemoglobin test,random blood sugar test,fasting blood sugar test,oral glucose tolerance test. Total of 20 subjects out of which five persons are healthy or non diabetic persons and the remaining 15 persons are of three categories namely patients with diabetes for less than 10 years, patients with diabetes for greater than 10 years, and patients with neuropathy; each category has five persons participating in this study.

This research work focuses at proposing a non-invasive method of screening diabetes using thermoregulation of the peroneal vessel. Since diabetes affects the peroneal vessel of subjects significantly, in this work the thermoregulatory behaviour of peroneal vessel is studied for selected application of hot and cold stress. The study involved 20 subjects, out of which five persons are healthy or non-diabetic persons and the remaining 15 persons are of three categories namely patients with diabetes for less than 10 years, patients with diabetes for greater than 10 years, and patients with neuropathy; each category has five persons participating in this study.The results obtained show the feasibility of disease screening by the proposed method although it is to be improved for further classification of the stages of disease progression and accuracy. From the

results, it is seen that the thermoregulatory response of the peroneal blood vessel in the leg to the cold stress is more meaningful as a disease marker compared to hot stress. From the classification results the accuracy of the proposed method is giving 75% for cold stress for a response time window of 2 minutes.

Keywords: Diabetic vasculopathy,cold stress,thermoregulatory impairment

Introduction

Diabetes is a metabolic disorder that causes high blood sugar or the human body does not produce sufficient insulin. Insulin hormone made by pancreas ,which helps in energy production. If human body doesn't produce enough insulin or it is not used properly then glucose stays in blood, too much glucose production in blood also causes other health problems.Type1,Type2, gestational diabetes are the most common types of diabetes. In Type1 diabetes body doesn't produce insulin and it attacks to immune system, destroys the cells in pancreas that produce insulin.Type1 diabetes can appear at any age and it usually diagnosed in children, young adults by taking insulin everyday prescribed by the doctor's advice to stay alive. In Type2 diabetes the body cells don't react to insulin. Gestational diabetes can appear in women during their pregnancy. High blood sugar leads to eye problems,heart disease(stroke),kidney diseases, dental diseases,foot problems[1].

Literature survey:

Peihua Chen.etal[2],discussed about the vascular diseases of diabetes like hyperlipemia,coronary heart disease,hypertension, and cerebral infaraction. In female patients around the age from 65-75 years who is suffering from diabetes macroangiopathy is peak prevalence.Ljiljana Trtica Majnarić.etal[3],discussed continuous monitoring of glucose levels of individual type1 diabetes patients,type2 diabetes by measuring glucose levels predictions at long term.N. Sneha1 and Tarun Gangil[4] presented the diagnosis of diabetic mellitus at an early stage by making use of significant features to design a prediction algorithm using machine learning and finding suitable classifier for clinical outcomes.Rakesh S Raj,Sanjay D S,Dr. Kusuma M,Dr. S Sampath[5],discussed the two different algorithms namely SVM,Navie Bayes for detection of medical records of diabetic subjects.in this work SVM,navie Bayes algoritms are compared in two algorithms SVM is giving more accuracy than Navie Bayes algorithm. Bhargavi Chatragadda,Supriya Kattula,Geetha Guthikonda[6],presented the diabetic disease prediction by application of data mining techniques. Data mining is method of extracting information which is stored in the dataset and analysing patterns.In this paper hue predictive analysis have done to foresee the disease's which composes of persistent and particular information related to it and sort of behaviour to be mentioned.in this work Apache spark software is used to detect the diabetes and spark is a cluster computing framework designed for fast efficient computation. It can handle more data points with low amount of computing power.

The primary objective of this
work is developing an applicable system to predict diabetes using
distributed machine learning based on big data platforms such
as Spar

The primary objective of this
work is developing an applicable system to predict diabetes using
distributed machine learning based on big data platforms such
as Spar

Krish Shah.etal[7],discussed two classifiers namely multinomial Navie Bayes classifier,Gaussian Navie Bayes classifier for detection of diabetes disease.In that Gaussian Naïve Bayes is identified as better classifier for identification of diabetes than Multinomial Navaive Bayes. Naveen Kishore.etal[8],presented the detection of diabetes by finding the subjects glucose level,blood pressure,pores,skin thickness,insulin,age and classifying subject is diabetic or healthy by different machine learning algorithms.

The primary objective of this
work is developing an applicable system to predict diabetes using
distributed machine learning based on big data platforms such
as Spar

The primary objective of this
work is developing an applicable system to predict diabetes using
distributed machine learning based on big data platforms such
as Spar

Sofia Benbelkacem.Baghdad Atmani [9], presented the random forest algorithm for diagnosis of diabetes. In this study the random forests proved more efficient compared with other machine learning algorithms.C.P.Ronald Reagan, S.Prasanna Devi[10],proposed the dosage prediction of type2 diabetic male subjects based on ANFIS algorithm.This algorithm combines both the features of artificial neural network and fuzzy logic where input data is trained and where as anfis toolbox is a five layered network.In this paper ANFIS and GA were combined for prediction of accurate dosage.

Methodology

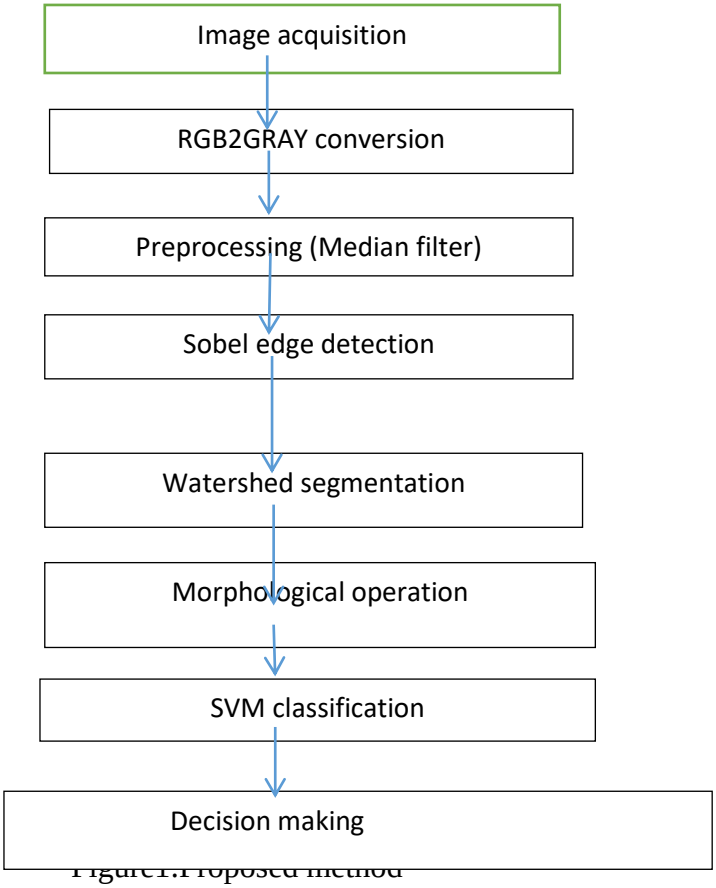

Figure1.Proposed method

A total of 20 subjects FIR images in which five are controlled group,15 are subject group i.e diabetic subject with lesser than and greater than 10 years,Neuropathy subjects were taken for experimentation and analysed. These images are converted from RGB to grey. The regions of interest (ROI) of healthy and diabetic subjects were then selected. For the selected region of interest for calf, knee, foot regions pre-processing is done through Median filtering and enhanced the images by contrast stretching . After enhancing the images ,the edges of the three regions are detected by sobel filter . The sobel edge detection is used for calculation of gradient of image intensity at each pixel within the image and the resulted image shows us how exactly the image changes at each pixel and from that how image pixel information can be represented an edge. Resulted edge pixel information of all the images was segmented through watershed algorithm. In this algorithm the different objects of images were separated form starting of user defined markers. After segmentation the morphological operations were done on diabetic ,healthy images for which selected parameters of all the images of diabetic ,healthy were calculated and classified by SVM classifier for identifying the subject is healthy or diabetic. The support vector machine is a supervised learning method used in medical disease diagnosis for classification[11].SVM finds a hyper plane having largest possible fraction of points of the same class on the same plane. Figure2 shows the SVM hyper plane.

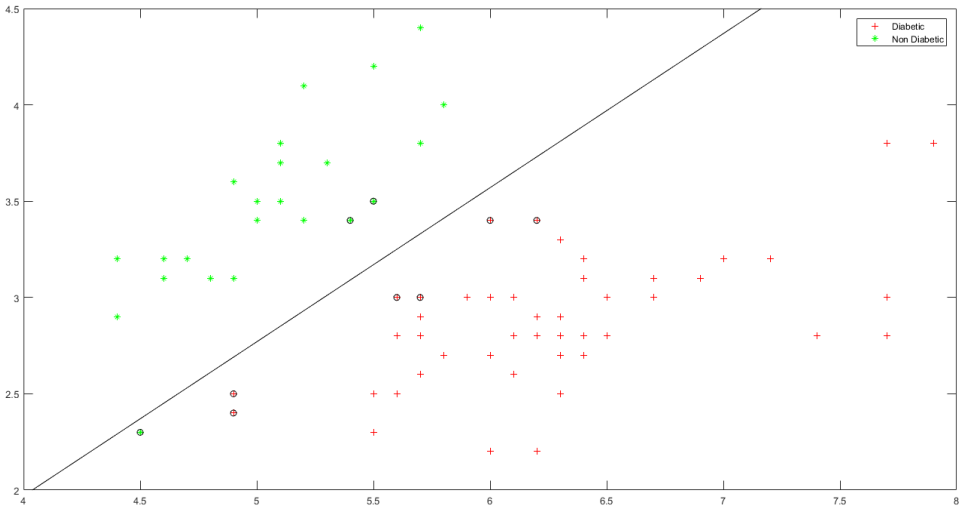

Figure2: SVM hyper plane

Cold Stress Experiment

With the reference of paper [12], The calf region is chosen as the area of interest since it is aimed to study the thermoregulatory impairment of peroneal artery with diabetes. A cold stress using a cold pack at 0°C was applied to the calf muscle where exactly the peroneal artery runs; the cold pack was kept for duration of 45 seconds after that it was removed. The temperature values of the calf were noted using a thermal imager as one image for every 20 seconds for a duration of 2 minutes. During this period due to thermoregulatory response of the subject's body, the calf area under test would try to heat up towards the temperature of the body. This procedure was repeated for all the subjects under observation. The corresponding temperature values were noted. Temperature values noted during the heating period of the calf area were compared and analysed. From the observed temperature values, ΔT value was

calculated for every subject as ΔT = Initial temperature (i.e., temperature at 0th sec) – temperature at 120th sec.ΔT Avg, the average of all ΔT values for the subjects under observations was obtained and analysed.

Hot Stress Experiment

The same calf region is chosen as the area of interest for hot stress experiment also.

A hot stress using hot water bag at 45-50°C was applied to the calf muscle where the peroneal artery runs; the pack was kept for duration of 45 seconds after which it was removed. The temperature values of the calf regions were noted using a thermal imager as one image for every 20 seconds for duration of 2 minutes. During this period due to thermoregulatory response of the subject's body the calf area under test would try to cool down towards the original temperature of the body. This producer was repeated for all the subjects. The corresponding temperature values were noted. Temperature values noted during the heating period of the calf area were compared and analysed. From the observed temperature values, ΔT value was calculated for every subject as ΔT = Initial temperature – temperature at 120th sec.The following statistical features are calculated to classify the diabetic and healthy subjects.

The statistical parameters namely covariance, standard deviation and mean, covariance, standard deviation,mean,Contrast,Correlation,Energy,Homogeneity,Standard_Deviation, Entropy, RMS, Variance, Smoothness, Kurtosis, Skewness, IDM were calculated.

image_contrast = max(grayImage(:)) - min(grayImage(:))

r = corr2(A,B) computes the correlation coefficient between A and B , where A and B are matrices or vectors of the same size.

Homogeneity of a region as the similarity between the largest element and the smallest element in that region.

energy=limit(z(t),t=infinity)

meanIntensity = mean(img(:))

Standard deviation

$$\sigma=\sqrt{\frac{\sum_{i=1}^{N}(Xi-\mu)^2}{N}}$$

Entropy:

Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image.

RMS:

$$X_{rms}=\sqrt{\frac{1}{N}\sum_{i=1}^{N}|X_n^2|}$$

Variance: A variance image is an image of the variances, that is the squares of the standard deviations, in the values of the input or output images

Smoothness:

It is used for smoothing images, reducing the amount of intensity variation between one pixel and the next resulting in image. Y = filter2(h,X) filters the data in X with the two-dimensional FIR filter in the matrix h.

Kurtosis:

$\gamma=\frac{1}{N}\sum_{i=1}^{N}\frac{Xi-u^4}{\sigma}$ -3

Skewness:

$$\frac{1}{N}\sum_{i=1}^{N}\frac{Xi-u^3}{\sigma}$$

Results

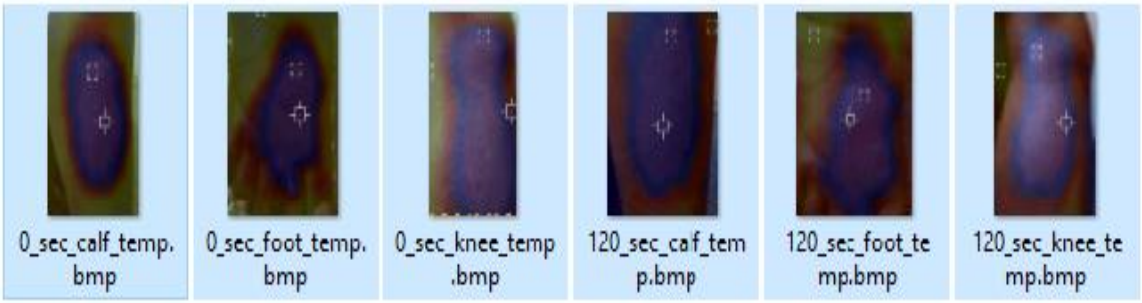

Figure3:healthy subject calf ,knee,foot images with 0th seconds and 120th seconds after applying cold stress

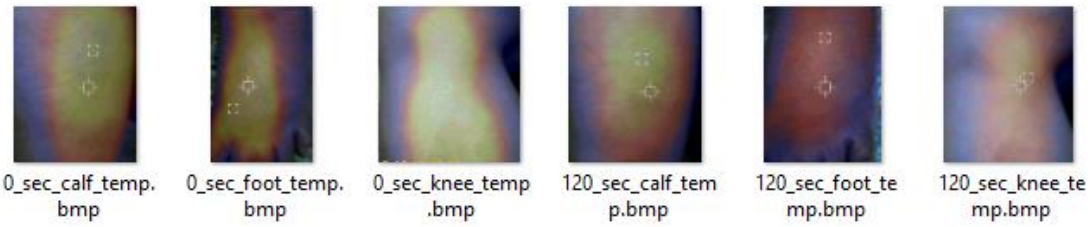

Figure4:Healthy subject calf ,knee,foot images with 0th seconds and 120th seconds after applying hot stress

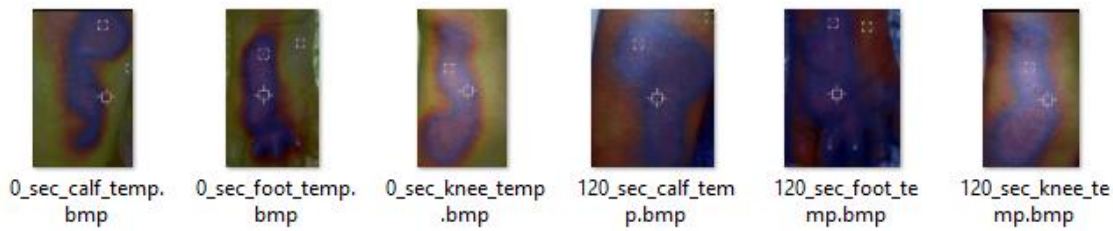

Figure5:diabetic subject calf ,knee,foot images with 0^{th} seconds and 120^{th} seconds after applying cold stress

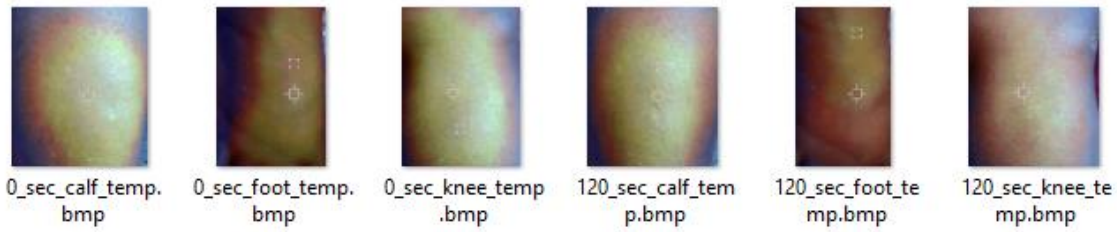

Figure6:diabetic subject calf ,knee,foot images with 0^{th} seconds and 120^{th} seconds after applying hot stress

Table1:The features of diabetic and healthy subjects using cold stress

Features	Normal			Diabetic >10 years			Diabetic <10 years			Neuropathy		
	Calf1	Knee1	Foot1	Calf1	Knee1	Foot1	Calf 1	Knee 1	Foot 1	Calf 1	Knee 1	Foot 1
Contrast	0.7147	0.5263	0.3943	0.4376	0.4714	0.5848	0.5621	0.4714	0.4549	0.6948	0.5636	0.6273
Correlation	0.0745	0.0421	0.0661	0.2	0.093	0.0946	0.0711	0.093	0.1018	0.0796	0.1253	0.0871
Energy	0.8233	0.702	0.7048	0.816	0.7355	0.7934	0.7704	0.7355	0.7816	0.8348	0.6923	0.7033
Homogeneity	0.9423	0.9101	0.9122	0.9435	0.9211	0.9362	0.9307	0.9211	0.936	0.9485	0.9081	0.9092
Mean	0.0072	0.0055	0.0036	0.0021	0.007	0.0069	0.0047	0.007	0.0042	0.0074	0.0092	0.0098
Standard deviation	0.1589	0.1117	0.1042	0.1043	0.1064	0.1064	0.1042	0.1064	0.102	0.1064	0.1144	0.1114
Entropy	1.959	3.4585	3.5766	2.0196	3.1291	2.3057	2.4267	3.1291	3.0598	2.0901	2.8625	2.936
RMS	0.1091	0.1118	0.1043	0.1043	0.1066	0.1066	0.1043	0.1066	0.1021	0.1066	0.1147	0.1118
Covariance	0.0119	0.0125	0.0109	0.0108	0.0113	0.0114	0.0109	0.0113	0.0104	0.0114	0.0131	0.0125
Smoothness	0.9478	0.9321	0.9085	0.8601	0.9519	0.9495	0.9257	0.9519	0.9261	0.95	0.9557	0.9566
Kurtosis	24.297	10.0162	6.9375	15.8693	12.849	22.71	19.3103	12.8497	19.3207	36.4764	9.5837	15.4439
Skewness	2.3098	1.1024	0.7334	1.3394	1.1735	2.4076	2.1571	1.1735	1.8293	3.9466	1.0893	1.9853
IDM	1.3818	1.3593	1.008	0.5638	1.0272	3.3813	2.289	1.0272	2.6931	5.3825	0.1565	0.6186

Table2: The features of diabetic and healthy subjects using hot stress

Images	Normal			Diabetic >10 years			Diabetic <10 years			Neuropathy		
	Calf2	Knee2	Foot2	Calf2	Knee2	Foot2	Calf 2	Knee 2	Foot 2	Calf 2	Knee 2	Foot 2
Contrast	0.5524	0.4373	0.412	0.8228	0.5032	0.313 7	0.86 63	0.552 3	0.551 6	0.622 5	0.387 4	0.528 6
Correlati on	0.1056	0.1058	0.203 5	0.0665	0.0429	0.199 2	0.03 83	0.117 1	0.063 1	0.068 7	0.074 3	0.163 7
Energy	0.8433	0.7659	0.748 9	0.7972	0.8101	0.747 1	0.82 77	0.741 1	0.721 9	0.855 4	0.819 9	0.778 7
Homoge neity	0.9511	0.9319	0.925 7	0.9366	0.9428	0.928 8	0.94 36	0.921 2	0.915 1	0.953 4	0.947 8	0.932 1
Mean	0.0072	0.0068	0.008	0.0098	0.0057	0.003 6	0.00 94	0.008 7	0.007 5	0.005 3	0.003 9	0.007 7
Standard deviation	0.0978	0.0998	0.104	0.1143	0.0979	0.102	0.11 14	0.108 8	0.108 9	0.101 9	0.089 7	0.106 3
Entropy	2.3286	3.1006	2.651 3	2.6119	2.4146	2.823	2.55 6	2.504	3.475 7	1.775	2.587 1	2.194 5
RMS	0.0981	0.1	0.104 3	0.1147	0.0981	0.102 1	0.11 18	0.109 1	0.109 1	0.102 1	0.089 8	0.106 6
Covarian ce	0.0096	0.01	0.010 8	0.0131	0.0096	0.010 4	0.01 25	0.011 9	0.011 8	0.010 4	0.008	0.011 3
Smoothn ess	0.9575	0.955	0.958 1	0.9559	0.9482	0.899 8	0.95 31	0.954 8	0.940 3	0.938	0.928 8	0.953 2
Kurtosis	31.6717	21.007 5	11.41 97	29.603 6	27.882 5	8.599 9	34.6 974	16.79 16	13.57 67	31.21 6	25.38	16.51 87
Skewnes s	3.2747	1.9736	1.211 7	3.5373	2.7537	0.723 5	4.01 37	1.723 3	1.589 5	3.200 5	2.358 4	0.528 6
IDM	3.658	3.0036	0.412	5.2046	2.8175	0.142 7	5.11 83		0.448 1	3.291 1	2.427	0.163 7

Figure1 shows the proposed methodology , Figure3:healthy subject calf ,knee, foot images with 0^{th} seconds and 120^{th} seconds after applying cold stress,_Figure4:Healthy subject calf ,knee,foot images with 0^{th} seconds and 120^{th} seconds after applying hot stress, Figure5:diabetic subject calf ,knee,foot images with 0^{th} seconds and 120^{th} seconds after applying cold stress, Figure6:diabetic subject calf ,knee,foot images with 0^{th} seconds and 120^{th} seconds after applying hot stress.Table1 shows the sample one subject features calculation using cold stress and table2 shows the one subject features calculation using hot stress.

Discussion:

A total of 20 subjects FIR images each of which five are control group and subject group i.e diabetic subject with greater than 10 years and lesser than 10 years ,Neuropathy ,Healthy subjects were taken for experimentation and images are obtained in jnana sanjeevani hospital,jayanagar. These images were then converted from RGB to grey. The region of

interest (ROI) was then selected. For the selected region of interest for calf,knee,foot regions pre-processing is done through Median filtering and enhanced the images by contrast stretching . after enhancing the images the sobel edge filter is used to detect the edges of all the calf,knee,foot regions of the diabetic, healthy subject images.Resulted edge pixel information of all the images were segmented through watershed algorithm.The results are tabulated (table1:cold stress values of healthy and diabetic,Table2:hot stress of healthy and diabetic subjects),from obtained results the calf region is showing the variations after application of cold stress in diabetic and non-diabetic subjects compared to hot stress,as the thermoregulation in diabetic subjects feet would be supplied of the impaired blood vessels whose vessel walls become hardened due to disease progression and they will lose their elasticity, Whereas the temperature of the healthy subjects feet is well regulated by the healthy blood vessel supplying so feet undergo smooth contractions and expansions.

Based on the selected features svm classification is performed to identify the Diabetic and non-diabetic subjects. To analyse the performance of classification,the accuracy is calculated. Four cases are considered to find the result of classifier accuracy i.e true positive,true negative,false positive,false negative.The classification is done on 20 subjects data. The training diabetic data set accuracy is 66 and the testing set accuracy is 75 for the SVM classifier. To improve more accuracy in the proposed method by significant increase in training set of samples.Figure7 shows receiver operating characteristic curve (ROC) which is drawn between false positive and true positive rate and it is describing the measure of positively predicting the disease.Figure8 shows the training set accuracy of the diabetic data set.

Dataset	accuracy	Specificity	sensitivity
Diabetes	75%	75%	50%

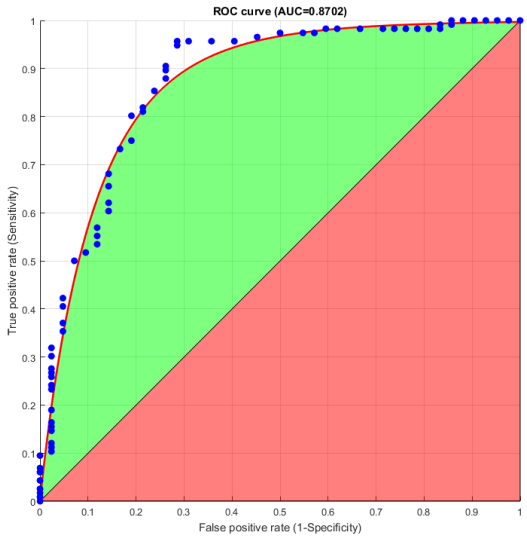

Figure7: ROC of SVM diabetic data

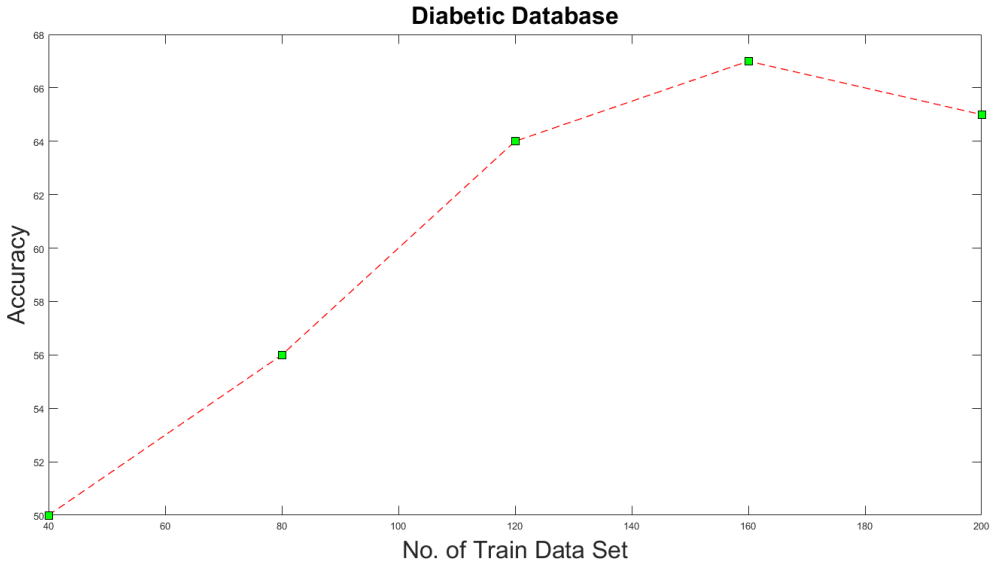

Figure8: Training set accuracy of Diabetes data set

Conclusion

20 subjects each of which five controlled group,subject group i.e diabetic greater than 10 years, diabetic lesser than 10 years, neuropathy with three different regions like calf, foot, knee duration of initial and 120 seconds are taken for analysis. The statistical parameters like correlation, contrast, energy, homogeneity, mean, standard deviation, entropy,RMS,covariance,smoothness,kurtosis,skewness,IDM are calculated. By using these parameters healthy and diabetic subjects are classified by using svm.The calf region is identified as suitable region to apply the cold stress to observe the thermoregulation of healthy and diabetic subjects,because the temperature of the healthy person's feet is well regulated by the healthy blood vessel supplying these feet undergo smooth contractions and expansions towards thermoregulation; whereas diabetic feet would be supplied of the impaired blood vessels whose walls become hardened due to disease progression and lose their elasticity.From the obtained results the accuracy of proposed method is 75% correctly classifying the subject is healthy or diabetic but the method to be said 100 % accurate after experimenting many more images and clinical trials.

References

[1] https://www.niddk.nih.gov/health-information/diabetes/overview/what-is-diabetes
[2] Peihua Chen, Chuandi Pan," Evaluation Of The Relationship Between Diabetes And Large
Blood Vessel Disease", Proceedings of the lASTED International Conference
Biomedical Engineering ,February 20 - 21, 2017,pp-200-207, DOl: JO.23J6/P.20l7.S52-00S
[3] Ljiljana Trtica Majnarić, František Babič, Zvonimir Bosnić4, Marijana Zekić-
Sušac and Thomas Wittlinger," The Use of Artifical Intelligence in Assessing Glucose Variability in Individuals with Diabetes Type 2 from Routine Primary Care Data",

International Journal of Diabetes and Clinical Research, DOI: 10.23937/2377-3634/1410121, Volume 7 | Issue 2,2020
[4]N. Sneha1and Tarun Gangil," Analysis of diabetes mellitus for early prediction using optimal features selection",Journal of big data,springer open access,February 2019,DOI: 10.1186/s40537-019-0175-6,pp-1-19
[5]Rakesh S Raj,Sanjay D S,Dr. Kusuma M,Dr. S Sampath," Comparison of Support Vector Machine and Naïve Bayes Classifiers for Predicting Diabetes", IEEE(2019),pp-41-45
[6]Bhargavi Chatragadda,Supriya Kattula,Geetha Guthikonda," Diabetes Data Prediction Using Spark and Analysis in Hue Over Big Data." 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT-2018), IEEE(2018), pp:658-663
[7]Krish Shah, Rajiv Punjabi, Priyanshi Shah, Dr Madhuri Rao," Real Time Diabetes Prediction using Naïve Bayes Classifier on Big Data of Healthcare", International Research Journal of Engineering and Technology (IRJET) ,Volume: 07 Issue: 05, May 2020,pp:102-107
[8]Naveen Kishore G, V.Rajesh, A.Vamsi Akki Reddy, K.Sumedh, T.Rajesh Sai Reddy,"Prediction Of Diabetes Using Machine Learning Classification Algorithms", INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 9, ISSUE 01, JANUARY 2020,pp:1805-1808
[9] Sofia Benbelkacem.Baghdad Atmani," Random Forests for Diabetes Diagnosis", 2019 International Conference on Computer and Information Sciences (ICCIS)
[10] C.P.Ronald Reagan, S.Prasanna Devi," An Android App For Intelligent Dosage Planning In Type2 Diabetes using anfisga",International Conference on Recent Trends in Information Technology IEEE(2014),PP-1-4
[11] V. Anuja Kumari, R.Chitra," Classification Of Diabetes Disease Using Support Vector Machine", International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 2, pp.1797-1801, (2013)
[12] Punal M arabi,Gayatri Joshi," Machine Vision for Early Diabetes Diagnosis", book chapter,In: Diabetic Foot: Prevention and Treatment ISBN: 978-1-53616-266-0,Editor: Gianni Romano © 2019 Nova Science Publishers, Inc.