# EGG SIGNAL CLASSIFICATION USING PRINCIPAL COMPONENT ANALYSIS

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# Abstract

The method is used to register the laryngeal behavior indirectly by measuring change in the electrical impedance across the throat during speak or voice. In this Electroglottography (EGG) signal acquisition, the electrodes are made of steel. They have the form of rectangles covering an area of 10.75 cm2. It is designed as a ring electrode encircling each of the two other electrodes. The electrodes are mounted on a flexible band whose length is adjusted to hold the electrodes in a steady position and to still allow the subject to comfortably speak and breathe naturally. The electrodes are mounted on a small holder which is pressed against the throat by hand. A signal generator supplies an AC sinusoidal current usually ranging from 2 MHz. The RF carrier signal is amplitude modulated by the modulating speech/voice signal and the demodulated signal is extracted. The variations in the signal correspond to the vocal fold abduction/laryngeal movement. For normal and pathology conditions, the results are recorded. These values form a feature vector, which reveals information regarding pathology. Principal Component Analysis technique (PCA) is used for classification, giving successful results for the specific data set considered.

Keywords: Electroglottography, Principal Component Analysis.

## I. INTRODUCTION

The voice pathology is very common in all over the world. In the current study the vocal fold abduction /laryngeal movement of normal and pathology patients have been recorded in terms of demodulated signals and MATLAB @6.1 supported Principal Component Analysis technique (PCA) is used for classification, giving successful results for the specific data set considered.

## **II. INSTRUMENTATION**

The electrodes are made of steel. They have the form of rectangles covering an area of 10.75 cm2. It may be designed as a separate electrode or as a ring electrode encircling each of the two other electrodes. The electrodes are mounted on a flexible band whose length may be adjusted to hold the electrodes in a steady position and to still allow the subject to comfortably speak and breathe naturally. The electrodes are mounted on a small holder, which is pressed against the throat by hand. A signal generator supplies an AC sinusoidal current usually ranging from 300 KHz to 5 MHz as shown in Figure.1.



Fig. 1. Instrumentation for EGG

The frequency selected for the above test is 2 MHz. This frequency is sufficiently high, so that the current capacitancively bypasses the less conductive skin layer without the use of additional conductive paste [1]. The generator may produce constant voltage or constitute constant current

source [1]. The supplied current is different for each particular device, but is not stronger than several milliamperes. The voltage between the electrodes depends on the tissue impedance [1-3]. The power dissipation of only several microwatts occurs at the level the subject's vocal folds. An integral part of the electroglottographic signal is the varying component generated by the vertical movement of the whole larynx. Therefore, the signal of rapid movements of the vocal folds is superimposed on the signal produced by the slower movements of the other structures. Fourcin & Abberton proposed the name Gx for the waveform of larynx movement and the name Lx for the vibration component. The Gx component originates, for example can be observed in swallowing, but it is caused by the vertical movement of the larynx, which is related to the voice quality setting of the raised/lowered larynx. Gx to calculate vocal fold abduction [1] The DC offset changes (Gx) can be evened out because, the effects of the varying larynx height are compensated by the use of additional electrodes or high pass filtering of the registered signal. The sensing electrode detects the current as it passes through the skin and the throat .The percentage of amplitude modulation of the received signal reflects the percentage change in 3 tissue impedance in the current's path. The output from the second RF transformer is then amplified using the above RF amplifier circuit. The output is demodulated using a diode detector circuit (Gx + Lx) . The output is then amplified using a OPAMP inverting amplifier (Gx) as shown in Fig. 2. The output spectra were reconcile





# **III. PCA ANALYSIS**

In the development of diagnostic or analytical methods for routine applications, only a small amount of data from a very large quantity of data is made use of from the point of view of expediency. This may lead to wrong interpretation and consequent faulty decision making, especially in clinical applications where personal judgment of the clinician may influence the decision. This kind of subjective evaluation of data can be avoided when we have enough data (e.g. a large number of spectra, each consisting of several data points) by appropriate mathematical / statistical analysis. Almost always, the enormous amount of data could be understood in terms of a much smaller number of components, called principal components or factors. This is equivalent to the situation, where any number of vectors in 3-dimentional spaces can be expressed in terms of 3 unit vectors and characteristic numbers for each vector. The n number of spectra with p data points each may be expressed in terms of a much smaller number of components or factors each with p data points. The identification of these unique factors is known as Principal Component Analysis (PCA) [4,5].

In real samples, there are usually many different variations that make up a spectrum: the constituents in the sample mixture, inter-constituent interactions, instrument variations such as detector noise, changing environmental conditions that affect absorbance, and differences in sample handling. Yet, even with all these complex changes occurring, there should be some finite number of independent variations occurring in the spectral data. Hopefully, the largest variations in the calibration set would be changes in the spectrum due to different concentrations of the constituent of the mixtures. If it were possible to calculate set of "variation spectra" that represented the changes in the intensities at all the wavelengths in the spectra, then this data could be used instead of raw spectral data for building the calibration model. These should be fewer common variations than the number of calibration spectra (in most cases), and thus, the number of calculations for the calibration equations will be reduced as well.

Presumably, the "variation spectra" could be used to reconstruct the spectrum of a sample by multiplying each one by an appropriate constant scaling factor and adding the results together until the reconstructed spectrum closely matches the sample spectrum. Obviously, each spectrum in the calibration set would have a different set of scaling constants for each variation since the concentrations of the constituent is different. Therefore, the scaling constant of each "spectrum" that must be added to reconstruct the unknown data should be related to the concentration of the constituents.

The "variation spectra" are often called "eigenvectors" (also called spectral loading, loading vectors, principal components or factors), from the methods used to calculate them. The scaling constants used to reconstruct the spectra are generally known as "scores".

Since the calculated eigenvectors came from the original calibration data, they must be somehow relating to the concentrations of the constituents that make up the samples. The same loading vectors can be used to predict "unknown" samples; thus only difference between spectra of samples with different constituent concentrations is the fraction of each loading added (scores).

## A. Signal Preprocessing

In the present study, we have used MATLAB @6.1 software tool is used to carryout smoothing, mathematical and statistical analysis.

## i) Smoothing

Highly noisy spectrum can be smoothened to a great extent using various smoothing functions. These include Fourier-domain smoothing, binomial smoothing etc. Fourier transforming the data, applying a filter function and then inverse Fourier transforming the data, accomplishes Fourier smoothing.

## IV. CLASSIFICATION

This method can classify samples into well-defined groups or categories based on a training set of similar samples without prior knowledge of the actual composition of group of training samples. The aim of this analysis is to identify unknown sample. The spectrum of sample is compared against the model to determine if it matches the training data for the model [6]. If the training set was constructed from spectra of samples that were of known quality, the model can accurately predict if the sample is of same quality by matching the spectrum and giving a "YES" or "NO" answer.

## A. Classification Parameters

## i) Eigenvectors And Scores

Eigenvectors are the spectral equivalents of principle components of the sample and scores corresponding to contribution of each principle component to a given sample. Multiplying the eigenvectors with the scores for that sample and adding the product for all scores can reconstruct each sample spectrum.

## ii) Residual Errors Or Spectral Residual

When each sample is predicted, a set of scores is found that best fits the model loading vectors to the sample spectrum. By using the calculated scores and calibration loading vectors, a new model reconstructed spectrum can be calculated. This new spectrum is what the PCA model thinks the sample spectrum look like. The residual errors or spectral residual is the difference between this spectrum and the actual prediction spectrum.

## iii) Mahalanobis Distance

It is very sensitive to inter variable changes in calibration data. The distance is measured in terms of standard deviations from the mean of the training samples The values give a statistical measure of how well the spectrum of unknown sample matches the original training spectra. Typical discrimination model is as shown in Figure 3.



## Fig. 3. Typical Discrimination Model

In PCA analysis, twenty spectra each from certified normal and pathology samples (details of spectra used are listed in table 1) were combined to see the best approach to prepare calibration sets in the two classes. It is seen that the eigenvalues decrease very rapidly and are almost zero after 7 to 8 factors, and about 99% of total spectral contribution come from these factors only as shown in Table 2. From the Table 2 and Figure 4, it can be seen that the eigenvalues decrease very rapidly and are almost zero after eight factors and also 100% of the total spectral

contribution come from these eight factors. This can be further confirmed by using an appropriate number of factors from the model set and regenerating the spectrum of any sample. The difference between the observed and regenerated spectrum, expressed as residual errors squared sum can be used as a measure of desired number of factors, as well accuracy of the model. In the present analysis it is found that four factors contributed to about 98% of total variance, and these four factors completely describe the spectra. The higher factors were found only to account for variations in day-to-day runs, noise etc., and did not improve sum of squared spectral residuals, or other parameters like average predicted Mahalanobis distance [7]. All final calculations were thus carried out with using only four factors. In this case, the statistical parameters like spectral residuals, Mahalanobis distances etc. are used for discrimination between normal and pathology cases.



Fig. 4. PCA Eigen values and total % variance for a model set of (a) 20 normal spectra (b) 20 pathology spectra.

**Table 1. Spectral Details** 

Spectral No	Sample Type	Mean age	Histopathology	Signal
1-20	Normal Standard Set	48 ± 6.1	Uninfected area - Normal	-
21-40	Pathology Standard set	48 ± 6.1	Laryngeal movement / vocal fold abduction	•
41-80	Normal Test Set	44 ± 7.5	Uninfected area - Normal	Normal
81-117	Pathology Test Set	44 ± 7.5	Laryngeal movement / vocal fold abduction	Pathology

Table 2. Factor number with corresponding eigen
values and total percentage variance for 20 normal
and 20 pathology calibration spectra

Factor Number	Eigen value	Total % Variance
1	453.980101	71.1774449
2	107.09752	88.0199317
3	50.1468976	95.841953
4	10.7986678	97.5396094
5	7.3732443	98.7601175
6	5.16731475	99.5704086
7	2.36394707	99.8509443
8	0.01421524	100

The Mahalanobis distance is normally expressed in units of standard deviation. For classification of oral tissues, we have employed the Mahalanobis distance (Mdistance) and spectral residual (the residual error squared sum) as the criteria. The M-distance can be represented by:

D2 = (S test) M - 1(S test) 1,

Where S test is the vector of scores and sum of squared spectral residuals for a given test sample, and M is given by  $S \notin S/(n-1)$ , where S contains the corresponding parameters for the calibration set (n standards).

Since the Mahalanobis distance is a standard deviation, a distance of »2 for a sample corresponds to a 5% probability of the sample belonging to the standard set, and higher distances will have still less probability. There are two main advantages in using D2 as a discriminating parameter. As seen from the equation, D2 explicitly accounts for any correlations between the variables, namely scores of factors. By fixing an upper limit for inclusion in any class represented by the standard calibration set for that class, we can possibly achieve any desired level of discrimination for staging.

We have made match mismatch tables of calibration set as well as test set samples (normal and malignant spectra) by comparing these with the normal calibration set considering the Mahalanobis distance (M-distance) of »3. The results are listed in tables 3, 4, 5 and 6.

# Table 3. Retrospective test of normal calibration set samples against calibration set of normal samples. Mean M distance for normal calibrated set is 1.0602±0.51 and Mean Spectral residual is 0.7569±0.028. Acceptance value is fixed to twice the mean M distance of normal calibration set.

Spectral				Spectral
number	Match	M. Distance	Limit test ***	residual
1	YES	0.7692	PASS (PPP)	0.5074
2	YES	1.0833	PASS (PPP)	0.9164
3	YES	0.8911	PASS (PPP)	0.7391
4	YES	1.0007	PASS (PPP)	0.1847
5	YES	0.8405	PASS (PPP)	0.5694
6	YES	1.7137	PASS (PPP)	1.5398
7	YES	0.8633	PASS (PPP)	0.2917
8	YES	1.3845	PASS (PPP)	0.2797
9	YES	1.0032	PASS (PPP)	0.5828
10	YES	1.6049	PASS (PPP)	1.3779
11	YES	1.7517	PASS (PPP)	1.5069
12	YES	1.7636	PASS (PP?)	1.3078
13	YES	0.7862	PASS (PPP)	0.9804
14	YES	0.5342	PASS (PPP)	0.7848
15	YES	0.5356	PASS (PPP)	0.6027
16	YES	0.7404	PASS (PPP)	0.6673
17	YES	1.2598	PASS (PPP)	0.5892
18	YES	0.8114	PASS (PPP)	0.5102
19	YES	1.0734	PASS (PPP)	0.9164
20	YES	1.2451	PASS (PPP)	0.5988

Table 4. Retrospective test of pathology calibration set samples against calibration set of normal samples. Mean M distance for normal calibrated set is 1.0602±0.51 and Mean Spectral residual is 0.7569±0.028. Acceptance value is fixed to twice the mean M distance of normal calibration set.

Spectral				Spectral
no	Match	M distance	Limit test **	residual
21	NO	7.8591	FAIL (FFF)	5.0169
22	NO	8.5018	FAIL (FFF)	5.3739
23	NO	7.3529	FAIL (FFF)	4.6739
24	NO	4.9425	FAIL (FFF)	3.3747
25	NO	8.5206	FAIL (FFF)	5.4821
26	NO	7.8294	FAIL (FFF)	5.0665
27	NO	5.4197	FAIL (FFF)	3.6616
28	NO	5.5963	FAIL (FFF)	3.6608
29	NO	5.1404	FAIL (FFF)	3.6272
30	NO	4.7382	FAIL (FFF)	5.0196
31	NO	5.4372	FAIL (FFF)	3.5981
32	NO	10.099	FAIL (FFF)	6.3894
33	NO	4.9682	FAIL (FFF)	2.4129
34	NO	4.9958	FAIL (FFF)	2.4899
35	NO	16.0364	FAIL (FFF)	9.5869
36	NO	4.5523	FAIL (FFF)	2.5229
37	NO	4.7859	FAIL (FFF)	2.8999
38	NO	4.6783	FAIL (FFF)	5.0518
39	NO	7.8393	FAIL (FFF)	5.0665
40	NO	8 9971	FAIL (FFF)	2 5192

Table 5. PCA of test normal samples against calibrated set of standard normal samples. Mean M distance for normal calibrated set is 1.0161 and Mean Spectral residual is 0.7112 Acceptance value of M - distance =3.0

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	Spectra1			Spectral	

number         Match         M. Distance         Limit test ***         residual           41         YES         0.8593         PASS (PPP)         0.6065           42         YES         1.1834         PASS (PPP)         0.6065           43         YES         0.8912         PASS (PPP)         0.8923           43         YES         0.8912         PASS (PPP)         0.8923           44         YES         1.1125         PASS (PPP)         0.6585           46         YES         1.8137         PASS (PPP)         0.6585           46         YES         1.0355         PASS (PPP)         0.4987           47         YES         1.0355         PASS (PPP)         0.6837           48         YES         1.3955         PASS (PPP)         0.6837           50         YES         1.6059         PASS (PPP)         0.6837           50         YES         1.5617         PASS (PPP)         1.4488           51         YES         0.8763         PASS (PPP)         0.8815           54         YES         0.8763         PASS (PPP)         0.7866           55         YES         0.7813         PASS (PPP)         0.7866 <th>Spectra1</th> <th></th> <th></th> <th></th> <th>Spectra1</th>	Spectra1				Spectra1
41         YES         0.8593         PASS (PPP)         0.6065           42         YES         1.1834         PASS (PPP)         0.9234           43         YES         0.8912         PASS (PPP)         0.0938           44         YES         1.1125         PASS (PPP)         0.08382           44         YES         1.1125         PASS (PPP)         0.06585           46         YES         1.8137         PASS (PPP)         1.6498           47         YES         0.7833         PASS (PPP)         0.2897           48         YES         1.1232         PASS (PPP)         0.6835           50         YES         1.6517         PASS (PPP)         0.68815           51         YES         1.5617         PASS (PPP)         1.4888           51         YES         0.8763         PASS (PPP)         0.7849           54         YES         0.6343         PASS (PPP)         0.7849           55         YES         0.8993         PASS (PPP)         0.7849           55         YES         0.8031         PASS (PPP)         0.7849           56         YES         0.8031         PASS (PPP)         0.7846	number	Match	M. Distance	Limit test ***	residual
42         YES         1.1834         PASS (PPP)         0.9234           43         YES         0.8912         PASS (PPP)         0.9342           44         YES         1.1125         PASS (PPP)         0.0058           45         YES         0.7503         PASS (PPP)         0.0658           46         YES         0.7303         PASS (PPP)         0.6683           47         YES         0.7833         PASS (PPP)         0.3917           48         YES         1.3055         PASS (PPP)         0.2897           49         YES         1.6959         PASS (PPP)         0.4837           50         YES         1.6959         PASS (PPP)         1.4888           51         YES         1.5617         PASS (PPP)         1.4888           51         YES         0.8763         PASS (PPP)         0.7819           53         YES         0.8933         PASS (PPP)         0.7849           55         YES         0.8931         PASS (PPP)         0.7482           58         YES         1.0108         PASS (PPP)         0.7482           58         YES         0.813         PASS (PPP)         0.7482      <	41	YES	0.8593	PASS (PPP)	0.6065
43         YES         0.8912         PASS (PPP)         0.8382           44         YES         1.1125         PASS (PPP)         0.0958           45         YES         0.7503         PASS (PPP)         0.6685           46         YES         1.8137         PASS (PPP)         0.6685           46         YES         1.8137         PASS (PPP)         0.3917           48         YES         1.3955         PASS (PPP)         0.2897           49         YES         1.6599         PASS (PPP)         0.6837           50         YES         1.6517         PASS (PPP)         0.6817           51         YES         1.5617         PASS (PPP)         0.6815           51         YES         0.8763         PASS (PPP)         0.7840           53         YES         0.8763         PASS (PPP)         0.7845           54         YES         0.8763         PASS (PPP)         0.7845           55         YES         0.8713         PASS (PP)         0.7866           56         YES         0.8513         PASS (PP)         0.4782           58         YES         0.8513         PASS (PP)         0.4782 <tr< td=""><td>42</td><td>YES</td><td>1.1834</td><td>PASS (PPP)</td><td>0.9234</td></tr<>	42	YES	1.1834	PASS (PPP)	0.9234
44         YES         1.1125         PASS (PPP)         0.0958           45         YES         0.7503         PASS (PPP)         0.6585           46         YES         0.7833         PASS (PPP)         0.6498           47         YES         0.7833         PASS (PPP)         0.6498           47         YES         0.7833         PASS (PPP)         0.3917           49         YES         1.3955         PASS (PPP)         0.6837           50         YES         1.6059         PASS (PPP)         1.6609           51         YES         1.5617         PASS (PPP)         1.6609           52         YES         0.6343         PASS (PPP)         0.7849           54         YES         0.6343         PASS (PPP)         0.7849           55         YES         0.7813         PASS (PPP)         0.7849           56         YES         0.8513         PASS (PPP)         0.7849           57         YES         0.7813         PASS (PPP)         0.7866           60         YES         1.0108         PASS (PPP)         0.7866           61         YES         0.8513         PASS (PPP)         0.4529	43	YES	0.8912	PASS (PPP)	0.8382
45         YES         0.7503         PASS (PPP)         0.6585           46         YES         1.8137         PASS (PPP)         0.6585           47         YES         0.7833         PASS (PPP)         0.2807           48         YES         1.3955         PASS (PPP)         0.2807           49         YES         1.6959         PASS (PPP)         0.2807           50         YES         1.6959         PASS (PPP)         1.4888           51         YES         1.5617         PASS (PPP)         1.4888           51         YES         0.8763         PASS (PPP)         0.8815           54         YES         0.8763         PASS (PPP)         0.7840           55         YES         0.893         PASS (PPP)         0.7840           56         YES         0.0844         PASS (PPP)         0.7482           57         YES         0.7813         PASS (PPP)         0.7482           58         YES         1.0108         PASS (PPP)         0.7482           59         YES         0.8513         PASS (PPP)         0.5786           60         YES         0.9366         PASS (PPP)         0.4359      <	44	YES	1.1125	PASS (PPP)	0.0958
46         YES         1.8137         PASS (PPP)         1.6498           47         YES         0.7833         PASS (PPP)         0.3917           48         YES         1.3955         PASS (PPP)         0.2897           49         YES         1.1232         PASS (PPP)         0.6837           50         YES         1.6959         PASS (PPP)         1.6888           51         YES         1.5617         PASS (PPP)         1.4888           51         YES         0.8763         PASS (PPP)         0.7849           53         YES         0.6813         PASS (PPP)         0.7849           54         YES         0.6343         PASS (PPP)         0.7849           55         YES         0.8939         PASS (PPP)         0.7806           56         YES         0.8913         PASS (PPP)         0.7806           57         YES         0.8513         PASS (PPP)         0.7866           58         YES         0.8513         PASS (PPP)         0.8116           61         YES         0.9366         PASS (PPP)         0.4325           64         YES         1.0687         PASS (PPP)         0.4325	45	YES	0.7503	PASS (PPP)	0.6585
47         YES         0.7833         PASS (PPP)         0.3917           48         YES         1.3955         PASS (PPP)         0.2897           49         YES         1.6959         PASS (PPP)         0.6837           50         YES         1.6959         PASS (PPP)         1.4888           51         YES         1.5617         PASS (PPP)         1.4688           51         YES         1.5547         PASS (PPP)         1.4129           53         YES         0.8763         PASS (PPP)         0.7849           54         YES         0.8903         PASS (PPP)         0.7849           55         YES         0.8903         PASS (PPP)         0.7849           56         YES         1.0844         PASS (PPP)         0.7866           58         YES         1.0108         PASS (PPP)         0.7866           60         YES         0.8513         PASS (PPP)         0.7866           61         YES         0.8569         PASS (PPP)         0.5786           62         YES         0.8719         PASS (PPP)         0.44259           63         YES         0.8719         PASS (PPP)         0.2527	46	YES	1.8137	PASS (PPP)	1.6498
48         YES         1.3955         PASS (PPP)         0.2897           49         YES         1.1232         PASS (PPP)         0.6837           50         YES         1.6959         PASS (PPP)         1.4888           51         YES         1.5617         PASS (PPP)         1.4888           51         YES         1.5617         PASS (PPP)         1.4488           52         YES         0.8763         PASS (PPP)         0.8815           54         YES         0.8763         PASS (PPP)         0.7840           55         YES         0.89763         PASS (PPP)         0.7845           56         YES         0.7813         PASS (PPP)         0.9732           57         YES         0.7813         PASS (PPP)         0.7462           58         YES         1.0108         PASS (PPP)         0.5786           60         YES         0.8513         PASS (PPP)         0.5786           61         YES         0.5569         PASS (PPP)         0.4259           64         YES         0.9366         PASS (PPP)         0.2527           65         YES         0.9319         PASS (PPP)         0.2527	47	YES	0.7833	PASS (PPP)	0.3917
49         YES         1.1232         PASS (PPP)         0.6837           50         YES         1.6959         PASS (PPP)         1.4888           51         YES         1.5617         PASS (PPP)         1.4669           52         YES         1.5547         PASS (PPP)         1.4669           53         YES         0.8763         PASS (PPP)         0.8815           54         YES         0.6343         PASS (PPP)         0.7849           55         YES         0.8993         PASS (PPP)         0.7849           56         YES         0.8993         PASS (PPP)         0.7849           57         YES         0.7813         PASS (PPP)         0.7920           58         YES         1.0844         PASS (PPP)         0.7940           59         YES         0.8513         PASS (PPP)         0.7432           60         YES         1.7228         PASS (PPP)         0.5786           61         YES         0.9366         PASS (PPP)         0.4329           63         YES         0.9379         PASS (PPP)         0.4329           64         YES         0.9303         PASS (PPP)         0.2327	48	YES	1.3955	PASS (PPP)	0.2897
50         YES         1.6959         PASS (PPP)         1.4888           51         YES         1.5617         PASS (PPP)         1.6060           52         YES         0.8763         PASS (PPP)         1.4129           53         YES         0.8763         PASS (PPP)         0.8815           54         YES         0.8993         PASS (PPP)         0.7849           55         YES         0.8993         PASS (PPP)         0.7066           56         YES         0.7813         PASS (PPP)         0.7482           58         YES         0.7813         PASS (PPP)         0.7482           58         YES         0.7813         PASS (PPP)         0.7482           58         YES         0.813         PASS (PPP)         0.7482           60         YES         0.8569         PASS (PP)         0.5786           61         YES         0.9569         PASS (PP)         0.4429           63         YES         0.8719         PASS (PP)         0.4425           64         YES         0.9366         PASS (PP)         0.2527           65         YES         0.9310         PASS (PP)         0.2533	49	YES	1.1232	PASS (PPP)	0.6837
51         YES         1.5617         PASS (PPP)         1.6069           52         YES         1.5547         PASS (PPP)         1.4129           53         YES         0.8763         PASS (PPP)         0.7845           54         YES         0.6343         PASS (PPP)         0.7845           55         YES         0.8763         PASS (PPP)         0.7845           55         YES         0.8993         PASS (PPP)         0.7066           56         YES         1.0844         PASS (PPP)         0.9332           57         YES         0.7813         PASS (PPP)         0.7066           59         YES         0.8513         PASS (PPP)         0.5786           60         YES         1.7228         PASS (PPP)         0.5786           61         YES         0.9366         PASS (PPP)         0.4329           63         YES         0.9366         PASS (PPP)         0.4329           64         YES         1.0687         PASS (PPP)         0.2527           65         YES         0.9319         PASS (PPP)         0.2527           66         YES         0.9319         PASS (PPP)         0.2527	50	YES	1.6959	PASS (PPP)	1.4888
52         YES         1.5547         PASS (PPP)         1.4129           53         YES         0.8763         PASS (PPP)         0.8815           54         YES         0.6343         PASS (PPP)         0.7849           55         YES         0.8993         PASS (PPP)         0.7849           55         YES         0.8993         PASS (PPP)         0.7849           56         YES         1.0844         PASS (PPP)         0.9322           57         YES         0.7813         PASS (PPP)         0.7420           58         YES         1.0108         PASS (PPP)         0.7462           59         YES         0.8113         PASS (PPP)         0.5786           60         YES         1.7228         PASS (PPP)         0.5166           61         YES         0.9366         PASS (PPP)         0.3452           63         YES         0.9307         PASS (PPP)         0.4250           64         YES         0.9303         PASS (PPP)         0.2523           65         YES         0.9303         PASS (PPP)         0.2594           64         YES         1.0133         PASS (PPP)         0.5928	51	YES	1.5617	PASS (PPP)	1.6069
53         YES         0.8763         PASS (PPP)         0.8815           54         YES         0.6343         PASS (PPP)         0.7849           55         YES         0.8993         PASS (PPP)         0.7066           56         YES         1.0844         PASS (PPP)         0.7066           56         YES         1.0844         PASS (PPP)         0.7066           57         YES         0.7813         PASS (PPP)         0.7422           58         YES         1.0108         PASS (PPP)         0.7742           59         YES         0.8113         PASS (PPP)         0.5786           60         YES         0.9366         PASS (PPP)         0.4516           61         YES         0.9366         PASS (PPP)         0.4529           63         YES         0.0893         PASS (PPP)         0.4529           64         YES         0.9893         PASS (PPP)         0.2527           65         YES         0.9893         PASS (PPP)         0.2597           66         YES         0.9319         PASS (PPP)         0.5785           69         YES         1.0133         PASS (PPP)         0.5785	52	YES	1.5547	PASS (PPP)	1.4129
54         YES         0.6343         PASS (PPP)         0.7849           55         YES         0.8993         PASS (PPP)         0.7066           56         YES         1.0844         PASS (PPP)         0.70232           57         YES         0.7813         PASS (PPP)         0.7423           58         YES         1.0844         PASS (PPP)         0.7423           58         YES         0.8513         PASS (PPP)         0.7766           60         YES         0.8513         PASS (PPP)         0.5786           61         YES         0.9366         PASS (PPP)         0.3432           63         YES         0.9366         PASS (PPP)         0.4259           64         YES         1.0687         PASS (PPP)         0.2523           65         YES         0.9303         PASS (PPP)         0.2526           66         YES         0.9313         PASS (PPP)         0.2529           68         YES         0.9313         PASS (PPP)         0.5928           70         YES         1.0138         PASS (PPP)         0.5928           70         YES         0.6243         PASS (PPP)         0.5928	53	YES	0.8763	PASS (PPP)	0.8815
55         YES         0.8993         PASS (PPP)         0.7066           56         YES         1.0844         PASS (PPP)         0.9232           57         YES         0.7813         PASS (PPP)         0.7482           58         YES         1.0108         PASS (PPP)         0.7482           59         YES         1.0108         PASS (PPP)         0.5786           60         YES         0.8513         PASS (PPP)         0.5786           61         YES         0.5569         PASS (PPP)         0.8143           61         YES         0.9366         PASS (PPP)         0.4259           63         YES         0.8710         PASS (PPP)         0.2327           64         YES         0.9819         PASS (PPP)         0.2537           66         YES         0.9319         PASS (PPP)         0.2533           66         YES         0.9319         PASS (PPP)         0.2533           68         YES         1.0133         PASS (PPP)         0.2592           70         YES         1.0238         PASS (PPP)         0.5928           70         YES         1.0238         PASS (PPP)         0.6924	54	YES	0.6343	PASS (PPP)	0.7849
56         YES         1.0844         PASS (PPP)         0.9332           57         YES         0.7813         PASS (PPP)         0.7482           58         YES         1.0108         PASS (PPP)         0.0769           59         YES         0.8513         PASS (PPP)         0.5786           60         YES         0.5560         PASS (PPP)         0.5786           61         YES         0.9366         PASS (PPP)         0.8116           62         YES         0.9366         PASS (PPP)         0.3432           63         YES         0.8719         PASS (PPP)         0.2527           64         YES         0.9893         PASS (PPP)         0.2527           65         YES         0.9893         PASS (PPP)         0.2537           66         YES         0.9893         PASS (PPP)         0.2593           67         YES         0.7813         PASS (PPP)         0.2592           68         YES         0.9303         PASS (PPP)         0.5928           70         YES         1.0133         PASS (PPP)         0.5928           70         YES         1.0258         PASS (PPP)         0.5848	55	YES	0.8993	PASS (PPP)	0.7066
57         YES         0.7813         PASS (PPP)         0.7482           58         YES         1.0108         PASS (PPP)         0.0769           59         YES         0.8513         PASS (PPP)         0.0769           59         YES         0.8513         PASS (PPP)         0.5786           60         YES         1.7228         PASS (PPP)         0.5176           61         YES         0.9366         PASS (PPP)         0.8116           62         YES         0.9366         PASS (PPP)         0.4329           63         YES         0.8719         PASS (PPP)         0.4250           64         YES         0.9893         PASS (PPP)         0.2527           65         YES         0.9893         PASS (PPP)         0.2527           66         YES         0.9303         PASS (PPP)         0.2528           67         YES         0.7613         PASS (PPP)         0.5928           70         YES         1.0133         PASS (PPP)         0.5928           70         YES         1.0258         PASS (PPP)         0.5928           70         YES         1.033         PASS (PPP)         0.5928      <	56	YES	1.0844	PASS (PPP)	0.9232
58         YES         1.0108         PASS (PPP)         0.0769           59         YES         0.8513         PASS (PPP)         0.5786           60         YES         0.8513         PASS (PPP)         0.5786           61         YES         0.5569         PASS (PPP)         0.8143           61         YES         0.9366         PASS (PPP)         0.8146           62         YES         0.9366         PASS (PPP)         0.4429           63         YES         0.8719         PASS (PPP)         0.2527           64         YES         0.9839         PASS (PPP)         0.2533           66         YES         0.9310         PASS (PPP)         0.2533           66         YES         0.9319         PASS (PPP)         0.2533           68         YES         0.9319         PASS (PPP)         0.2593           69         YES         1.0133         PASS (PPP)         0.5928           70         YES         1.0258         PASS (PPP)         0.6921           71         YES         0.7673         PASS (PPP)         0.6924           72         YES         0.7357         PASS (PPP)         0.6773	57	YES	0.7813	PASS (PPP)	0.7482
59         YES         0.8513         PASS (PPP)         0.5786           60         YES         1.7228         PASS (PPP)         0.434           61         YES         0.5366         PASS (PPP)         0.8116           62         YES         0.9366         PASS (PPP)         0.3432           63         YES         0.9366         PASS (PPP)         0.4259           64         YES         1.0687         PASS (PPP)         0.2527           65         YES         0.9893         PASS (PPP)         0.2527           66         YES         0.9319         PASS (PPP)         0.2527           67         YES         0.9303         PASS (PPP)         0.2535           68         YES         0.9303         PASS (PPP)         0.2592           70         YES         1.0138         PASS (PPP)         0.5928           70         YES         1.0258         PASS (PPP)         0.6962           72         YES         0.6243         PASS (PPP)         0.6962           72         YES         0.7357         PASS (PPP)         0.5848           73         YES         0.7357         PASS (PPP)         0.5872      <	58	YES	1.0108	PASS (PPP)	0.0769
60         YES         1.7228         PASS (PPP)         1.5434           61         YES         0.5569         PASS (PPP)         0.8116           62         YES         0.9366         PASS (PPP)         0.4342           63         YES         0.8719         PASS (PPP)         0.4259           64         YES         1.0687         PASS (PPP)         0.2527           65         YES         0.9819         PASS (PPP)         0.2533           66         YES         0.9819         PASS (PPP)         0.2533           66         YES         0.7813         PASS (PPP)         0.2597           68         YES         0.7813         PASS (PPP)         0.5785           69         YES         1.0133         PASS (PPP)         0.5928           70         YES         0.7763         PASS (PPP)         0.6924           71         YES         0.7377         PASS (PPP)         0.6943           72         YES         0.7405         PASS (PPP)         0.6972           74         YES         0.7405         PASS (PPP)         0.6773           75         YES         1.2344         PASS (PPP)         0.5882	59	YES	0.8513	PASS (PPP)	0.5786
61         YES         0.5569         PASS (PPP)         0.8116           62         YES         0.9366         PASS (PPP)         0.3452           63         YES         0.8719         PASS (PPP)         0.4259           64         YES         1.0687         PASS (PPP)         0.2527           65         YES         0.9939         PASS (PPP)         0.2527           66         YES         0.99319         PASS (PPP)         0.2527           66         YES         0.99319         PASS (PPP)         0.2527           66         YES         0.9319         PASS (PPP)         0.2527           67         YES         0.7813         PASS (PPP)         0.2528           68         YES         0.9319         PASS (PPP)         0.5785           69         YES         1.0133         PASS (PPP)         0.5785           69         YES         1.0238         PASS (PPP)         0.6924           71         YES         0.7357         PASS (PPP)         0.5848           73         YES         0.7357         PASS (PPP)         0.6773           75         YES         1.2699         PASS (PPP)         0.5872	60	YES	1.7228	PASS (PPP)	1.5434
62         YES         0.9366         PASS (PPP)         0.3432           63         YES         0.8719         PASS (PPP)         0.4259           64         YES         1.0687         PASS (PPP)         0.2527           65         YES         0.9893         PASS (PPP)         0.2527           66         YES         0.9893         PASS (PPP)         0.2537           66         YES         0.9319         PASS (PPP)         0.2599           66         YES         0.7813         PASS (PPP)         0.2399           68         YES         0.9319         PASS (PPP)         0.5783           69         YES         1.0133         PASS (PPP)         0.5785           70         YES         1.0258         PASS (PPP)         0.6902           72         YES         0.6243         PASS (PPP)         0.6962           72         YES         0.6243         PASS (PPP)         0.7662           74         YES         0.7357         PASS (PPP)         0.6773           75         YES         1.2344         PASS (PPP)         0.5872           76         YES         1.2344         PASS (PPP)         0.5464	61	YES	0.5569	PASS (PPP)	0.8116
63         YES         0.8719         PASS (PPP)         0.4259           64         YES         1.0687         PASS (PPP)         0.2527           65         YES         0.9893         PASS (PPP)         0.2537           66         YES         0.9893         PASS (PPP)         1.0016           67         YES         0.7813         PASS (PPP)         0.2537           66         YES         0.7813         PASS (PPP)         0.2597           68         YES         0.7813         PASS (PPP)         0.5785           69         YES         1.0133         PASS (PPP)         0.5785           69         YES         1.0238         PASS (PPP)         0.5284           70         YES         0.763         PASS (PPP)         0.6324           71         YES         0.7435         PASS (PPP)         0.5848           73         YES         0.7357         PASS (PPP)         0.5643           74         YES         0.7405         PASS (PPP)         0.5677           75         YES         1.2699         PASS (PPP)         0.5872           76         YES         0.8345         PASS (PPP)         0.5872      <	62	YES	0.9366	PASS (PPP)	0.3452
64         YES         1.0687         PASS (PPP)         0.2527           65         YES         0.9893         PASS (PPP)         0.2537           66         YES         0.9819         PASS (PPP)         0.2537           66         YES         0.9319         PASS (PPP)         1.0016           67         YES         0.7813         PASS (PPP)         0.2593           69         YES         0.9319         PASS (PPP)         0.2590           69         YES         0.9303         PASS (PPP)         0.2592           70         YES         1.0133         PASS (PPP)         0.5928           70         YES         1.0258         PASS (PPP)         0.6962           72         YES         0.6243         PASS (PPP)         0.5848           73         YES         0.7357         PASS (PPP)         0.6773           74         YES         1.2699         PASS (PPP)         0.5872           76         YES         1.2699         PASS (PPP)         0.5872           76         YES         1.2344         PASS (PPP)         0.4802           77         YES         1.2344         PASS (PPP)         0.5904	63	YES	0.8719	PASS (PPP)	0.4259
65         YES         0.9893         PASS (PPP)         0.2553           66         YES         0.9319         PASS (PPP)         1.0016           67         YES         0.7813         PASS (PPP)         0.2299           68         YES         0.9303         PASS (PPP)         0.2299           68         YES         0.9303         PASS (PPP)         0.5785           69         YES         1.0138         PASS (PPP)         0.5928           70         YES         0.763         PASS (PPP)         0.6942           71         YES         0.7763         PASS (PPP)         0.6962           72         YES         0.6243         PASS (PPP)         0.6962           73         YES         0.7405         PASS (PPP)         0.6973           74         YES         0.7405         PASS (PPP)         0.6773           75         YES         1.2049         PASS (PPP)         0.5882           77         YES         1.2344         PASS (PPP)         0.4802           77         YES         1.2344         PASS (PPP)         0.5994           78         YES         1.2355         PASS (PPP)         0.5995      <	64	YES	1.0687	PASS (PPP)	0.2527
66         YES         0.9319         PASS (PPP)         1.0016           67         YES         0.7813         PASS (PPP)         0.2290           68         YES         0.9303         PASS (PPP)         0.5785           69         YES         1.0133         PASS (PPP)         0.5785           70         YES         1.0258         PASS (PPP)         0.6294           71         YES         0.763         PASS (PPP)         0.6924           72         YES         0.763         PASS (PPP)         0.5848           73         YES         0.7377         PASS (PPP)         0.5848           73         YES         0.7405         PASS (PPP)         0.5848           75         YES         1.2099         PASS (PPP)         0.5872           76         YES         1.2344         PASS (PPP)         0.5872           77         YES         1.2344         PASS (PPP)         0.9464           78         YES         1.436         PASS (PPP)         0.5892           79         YES         1.2344         PASS (PPP)         0.5846	65	YES	0.9893	PASS (PPP)	0.2553
67         YES         0.7813         PASS (PPP)         0.2299           68         YES         0.9303         PASS (PPP)         0.5785           69         YES         1.0133         PASS (PPP)         0.5785           70         YES         1.0258         PASS (PPP)         0.6902           71         YES         1.0278         PASS (PPP)         0.6902           72         YES         0.6243         PASS (PPP)         0.6962           72         YES         0.6243         PASS (PPP)         0.5948           73         YES         0.7357         PASS (PPP)         0.7073           74         YES         0.7405         PASS (PPP)         0.6773           75         YES         1.2699         PASS (PPP)         0.5872           76         YES         1.2344         PASS (PPP)         0.4802           77         YES         1.2344         PASS (PPP)         0.5962           78         YES         1.436         PASS (PPP)         0.5962           79         YES         1.2346         PASS (PPP)         0.5962	66	YES	0.9319	PASS (PPP)	1.0016
68         YES         0.9303         PASS (PPP)         0.5785           69         YES         1.0133         PASS (PPP)         0.5928           70         YES         1.0258         PASS (PPP)         0.6294           71         YES         0.7763         PASS (PPP)         0.6294           72         YES         0.6243         PASS (PPP)         0.5928           73         YES         0.7357         PASS (PPP)         0.5948           73         YES         0.7405         PASS (PPP)         0.69773           75         YES         1.2699         PASS (PPP)         0.6773           76         YES         1.2344         PASS (PPP)         0.4802           77         YES         1.2344         PASS (PPP)         0.5994           78         YES         1.2346         PASS (PPP)         0.5997           79         YES         1.2346         PASS (PPP)         0.5997	67	YES	0.7813	PASS (PPP)	0.2299
69         YES         1.0133         PASS (PPP)         0.5928           70         YES         1.0258         PASS (PPP)         0.6294           71         YES         0.7763         PASS (PPP)         0.6962           72         YES         0.6243         PASS (PPP)         0.5848           73         YES         0.7377         PASS (PPP)         0.5848           74         YES         0.7405         PASS (PPP)         0.6773           75         YES         1.2699         PASS (PPP)         0.5872           76         YES         0.8345         PASS (PPP)         0.5872           77         YES         1.2344         PASS (PPP)         0.9464           78         YES         1.2346         PASS (PPP)         0.5992           79         YES         1.2346         PASS (PPP)         0.5464	68	YES	0.9303	PASS (PPP)	0.5785
70         YES         1.0258         PASS (PPP)         0.6294           71         YES         0.773         PASS (PPP)         0.6962           72         YES         0.6243         PASS (PPP)         0.5848           73         YES         0.7357         PASS (PPP)         0.702           74         YES         0.7357         PASS (PPP)         0.703           75         YES         1.2699         PASS (PPP)         0.5872           76         YES         0.8345         PASS (PPP)         0.5872           77         YES         1.2344         PASS (PPP)         0.4802           78         YES         1.2346         PASS (PPP)         0.5992           79         YES         1.2346         PASS (PPP)         0.5462	69	YES	1.0133	PASS (PPP)	0.5928
71         YES         0.7763         PASS (PPP)         0.6962           72         YES         0.6243         PASS (PPP)         0.5848           73         YES         0.7357         PASS (PPP)         0.7027           74         YES         0.7405         PASS (PPP)         0.6773           75         YES         1.2699         PASS (PPP)         0.5842           76         YES         0.8345         PASS (PPP)         0.4802           77         YES         1.2344         PASS (PPP)         0.9464           78         YES         1.2346         PASS (PPP)         0.5992           79         YES         1.2354         PASS (PPP)         0.5992           79         YES         1.2354         PASS (PPP)         0.9464           78         YES         1.2355         PASS (PPP)         0.5995           79         YES         0.5555         PASS (PPP)         0.5995	70	YES	1.0258	PASS (PPP)	0.6294
72         YES         0.6243         PASS (PPP)         0.5848           73         YES         0.7357         PASS (PPP)         0.7027           74         YES         0.7405         PASS (PPP)         0.6773           75         YES         1.2699         PASS (PPP)         0.5872           76         YES         0.8345         PASS (PPP)         0.5872           77         YES         1.2344         PASS (PPP)         0.9464           78         YES         1.2346         PASS (PPP)         0.5994           79         YES         1.2345         PASS (PPP)         0.5964	71	YES	0.7763	PASS (PPP)	0.6962
73         YES         0.7357         PASS (PPP)         0.7027           74         YES         0.7405         PASS (PPP)         0.6773           75         YES         1.2699         PASS (PPP)         0.5872           76         YES         0.8345         PASS (PPP)         0.4802           77         YES         1.2344         PASS (PPP)         0.9464           78         YES         1.2436         PASS (PPP)         0.5909           79         YES         1.2355         PASS (PPP)         0.5090	72	YES	0.6243	PASS (PPP)	0.5848
74         YES         0.7405         PASS (PPP)         0.6773           75         YES         1.2699         PASS (PP)         0.5872           76         YES         0.8345         PASS (PP)         0.4802           77         YES         1.2344         PASS (PP)         0.9464           78         YES         1.2345         PASS (PP)         0.5992           79         YES         1.2355         PASS (PP)         0.5992           79         YES         1.2355         PASS (PP)         0.5995	73	YES	0.7357	PASS (PPP)	0.7027
75         YES         1.2699         PASS (PPP)         0.5872           76         YES         0.8345         PASS (PPP)         0.4802           77         YES         1.2344         PASS (PPP)         0.9464           78         YES         1.2436         PASS (PPP)         0.5969           79         YES         0.5555         PASS (PPP)         0.5944	74	YES	0.7405	PASS (PPP)	0.6773
76         YES         0.8345         PASS (PPP)         0.4802           77         YES         1.2344         PASS (PPP)         0.9464           78         YES         1.2436         PASS (PPP)         0.5969           79         YES         0.5555         PASS (PPP)         0.5944	75	YES	1.2699	PASS (PPP)	0.5872
77         YES         1.2344         PASS (PPP)         0.9464           78         YES         1.2436         PASS (PPP)         0.5999           79         YES         0.5555         PASS (PPP)         0.8145	76	YES	0.8345	PASS (PPP)	0.4802
78         YES         1.2436         PASS (PPP)         0.5999           79         YES         0.5555         PASS (PPP)         0.8145	77	YES	1.2344	PASS (PPP)	0.9464
79 YES 0.5555 PASS (PPP) 0.8145	78	YES	1.2436	PASS (PPP)	0.5999
	79	YES	0.5555	PASS (PPP)	0.8145
80 YES 0.9457 PASS (PPP) 0.3543	80	YES	0.9457	PASS (PPP)	0.3543

# V. DISCUSSION

In PCA analysis, we have used twenty spectra each from certified normal and malignant oral tissue samples and calibration set is built. As mentioned earlier, we have used four factors for all final calculations and M-distance and spectral residual as discrimination parameters. Figure 5, shows a plot of the M-distance against residual errors squared sum for a new set of 77 samples (40 normal + 37 pathology), compared to a standard set of normal spectra. It is clearly seen from the plot that all samples diagnosed as normal by pathological examination in the new set fall in the lower left-hand corner of the plot. If we take a Mdistance of 1 as acceptance, then almost all the samples classified as normal samples fall within 3 times this value, while all samples classified as pathology lie far outside. The specificity and sensitivity of this technique is thus guite good, 100% and 83.8% respectively (shown in table 7). A closer observation of Figure 5 shows a very small number of samples outside the acceptable range of either normal or pathology species. i.e. the overlap between two sets are negligible up to mean +-2 standard deviations, which shows the probability of samples being in the respective clusters to be about 97% and finding them out of the cluster is less than 3%. All the pathology samples have a Mdistance >>2, indicating the probability of their belonging to the normal group, practically zero. All the normal samples have a M-distance much lower than 2, showing the probability of these being out of the group negligible. Once the validity of the standard calibration sets was established, we carried out a limited test on the predictive value of the method. For this 77 additional spectra (40 normal and 37 pathology spectra) were predicted with the standard calibration set prepared earlier.



Fig. 5. Plot of spectral residual v/s M.distance- normal and pathology spectra against normal calibration set

For better discrimination of normal and pathology spectra, we have used match mismatch criteria by comparing calibration set as well as test set samples (normal and pathology spectra) with the normal calibration set considering the Mahalanobis distance (M-distance) of »3. According to this criterion, all spectra that fall within the limits are labeled as 'match' and others are labeled as 'no match'. When a set of 20 spectra of normal samples is used as calibration standard, all normal spectra of the calibration set were shown 'match' and all pathology calibration set spectra were shown 'no match' as shown in Table 3 and 4 respectively. In this case all the normal spectra are tested retrospectively by rotating out each spectrum from the calibration set, while all the pathology spectra are tested prospectively.

PCA of this region was then repeated in the prediction mode for testing match or mismatch of test samples with the normal calibration set. As expected when the set of 40 spectra of normal samples were shown 'match' and 31 out of 37 pathology spectra were shown 'no match' as shown in Table 5 and 6. Six pathology test spectra which shown match when normal calibration set was used for prediction of 37 pathology spectra may be due to the recording of the spectra from normal site of the pathology tissue. From the tables it can be seen that the results are very satisfactory and the PCA using match mismatch can be used for the discrimination between normal and pathology cases.

We have also plotted M-distance versus sample number for 117 spectra (20+40 normal and 20+ 37 pathology) as shown in Figure 6.



Fig. 6. Classification of 117 spectra (20+40 normal, 20+37 pathology). Sample number against M. distance for normal and pathology calibration and test spectra

Table 6. PCA of test pathology samples against calibrated set of standard normal samples. Mean M distance for normal calibrated set is 1.0161 and Mean Spectral residual is 0.7112. Acceptance value of M - distance =3.0

Spectral         Initial res         Distance         Limit res         Spectral           81         NO         7.8890         FALL (FFF)         stational           81         NO         7.8890         FALL (FFF)         stational           82         NO         7.0679         FALL (FFF)         stational           83         NO         7.0679         FALL (FFF)         stational           84         NO         4.7855         FALL (FFF)         stational           86         NO         7.3344         FALL (FFF)         stational           86         NO         7.3444         FALL (FFF)         stational           87         NO         stational         FALL (FFF)         stational           89         NO         stational         FALL (FFF)         stational           89         NO         stational         FALL (FFF)         stational           89         YES         2.1505         PASS.(FFF)         stational           91         NO         stational         FALL (FFF)         stational           92         NO         15446         FALL (FFF)         stational           91         NO         stational         <	Countral 1	Matali	M Distance	T insident \$88	Consistent 1
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	spectral	Match	M. Distance	Linuitest	specual
ab         Ab         2.8893         FAL (FF)         3.1173           b2         NO         8.7124         FAL (FF)         3.1173           b3         NO         7.3679         FAL (FF)         3.4733           b3         NO         7.3679         FAL (FF)         3.4764           b4         NO         4.7853         FAL (FF)         3.4764           b5         NO         8.3322         FAL (FF)         3.4764           b6         NO         7.3394         FAL (FF)         3.4764           b7         NO         3.4124         FAL (FF)         3.4764           b7         NO         5.4124         FAL (FF)         3.4731           b8         NO         5.3765         FAL (FF)         3.4731           b9         YES         1.5133         PASS(PP)         1.3031           b9         NO         5.4143         FAL (FF)         2.4266           b9         NO         4.1234         FAL (FF)         2.4266           b9         NO         4.443         FAL (FF)         2.4266           b9         NO         4.443         FAL (FF)         6.4433           b10         NO	number	NO	7,8800	EAU (EEE)	festduar
bit         bi	81	NO	7.8899	FAIL (FFF)	5.1179
83         NO         7.3079         FALL (FF)         3.4764           84         NO         4.7835         FALL (FF)         3.4764           85         NO         8.3322         FALL (FF)         3.4764           86         NO         7.3394         FALL (FF)         3.4764           86         NO         5.322         FALL (FF)         3.1712           87         NO         5.4124         FALL (FF)         3.5431           89         YES         2.1505         PASC(PP)         1.4335           90         YES         1.7433         PASC(PP)         1.4336           91         NO         5.5472         FALL (FF)         3.5643           92         NO         1.0103         FALL (FF)         4.3364           93         NO         4.2334         FALL (FF)         4.434           94         NO         5.4443         FALL (FF)         2.4333           95         NO         1.61346         FALL (FF)         2.4363           96         NO         5.4443         FALL (FF)         2.4363           97         NO         5.4443         FALL (FF)         6.4322           98	82	NO	8.7124	FAIL (FFF)	5.4739
84         NO         4,855         FALL (FF)         3,4764           85         NO         8,5322         FALL (FF)         5,4921           86         NO         7,9394         FALL (FF)         5,4921           87         NO         5,4724         FALL (FF)         5,4921           88         NO         5,5765         FALL (FF)         3,644           89         NO         5,5765         FALL (FF)         3,664           89         YES         2,1505         PASS(PPP)         1,6373           90         YES         1,7433         PASS(PPP)         1,6373           91         NO         5,5472         FALL (FF)         3,5675           92         NO         10.103         FALL (FF)         4,6433           95         NO         4,1235         FALL (FF)         2,4266           94         NO         4,5434         FALL (FF)         2,4333           96         NO         5,4444         FALL (FF)         2,4364           97         NO         6,4435         FALL (FF)         6,6433           100         NO         8,8766         FALL (FF)         6,6434           100	83	NO	/.36/9	FAIL (FFF)	4.6924
85         NO         8.5.322         FALL (FF)         5.4921           86         NO         7.3934         FALL (FF)         5.1772           87         NO         5.4124         FALL (FF)         5.1772           87         NO         5.4124         FALL (FF)         5.1772           88         NO         5.5765         FALL (FF)         3.5643           89         YES         2.1505         PASS(PP)         1.4336           90         YES         1.7433         PASS(PP)         1.4336           91         NO         5.5472         FALL (FF)         5.6453           92         NO         10.103         FALL (FF)         2.464           94         NO         4.5434         FALL (FF)         2.4933           95         NO         1.61346         FALL (FF)         2.4933           96         NO         5.4443         FALL (FF)         2.6434           97         NO         6.4636         FALL (FF)         2.6434           98         YES         2.5643         PASC(PP)         1.44545           100         NO         8.466         FALL (FF)         6.6432           101	84	NO	4.7835	FAIL (FFF)	3.4764
86         NO         7.9394         FALL (FF)         3.6741           87         NO         5.4124         FALL (FF)         3.6544           88         NO         5.5765         FALL (FF)         3.6644           89         YES         2.1505         FASL(PFP)         1.6373           90         YES         1.7433         PASS(PPP)         1.6373           90         YES         1.7433         PASS(PPP)         1.6373           91         NO         5.5472         FALL (FFF)         3.5675           92         NO         10.103         FALL (FFF)         3.5675           93         NO         4.1235         FALL (FFF)         4.266           94         NO         4.5434         FALL (FFF)         2.4266           94         NO         5.4414         FALL (FFF)         8.6433           96         NO         5.44443         FALL (FFF)         8.6433           97         NO         6.4636         FALL (FFF)         6.6438           100         NO         8.8766         FALL (FFF)         6.6438           102         NO         8.7603         FALL (FFF)         6.5599 <td< td=""><td>85</td><td>NO</td><td>8.5322</td><td>FAIL (FFF)</td><td>5.4921</td></td<>	85	NO	8.5322	FAIL (FFF)	5.4921
87         NO         5.4124         FALL (FF)         3.6544           88         NO         5.5765         FALL (FF)         3.5643           99         YES         2.1505         PASS(PP)         1.4336           90         YES         1.7433         PASS(PP)         1.4366           91         NO         5.5472         FALL (FF)         5.6473           92         NO         10.103         FALL (FF)         6.4322           93         NO         4.1235         FALL (FF)         2.4266           94         NO         4.5434         FALL (FF)         2.4333           95         NO         16.1346         FALL (FF)         2.4343           97         NO         6.4636         FALL (FF)         2.3434           97         NO         6.4636         FALL (FF)         2.3434           97         NO         6.4636         FALL (FF)         6.4532           98         YES         2.3643         FALL (FF)         6.3438           90         NO         7.8454         FALL (FF)         6.5439           101         NO         8.1602         FALL (FF)         5.6539           102	86	NO	7.9394	FAIL (FFF)	5.1772
88         NO         5.5/65         FALL (FF)         3.5643           89         YES         2.1505         PASS(PPP)         1.6373           90         YES         1.7433         PASS(PPP)         1.6373           90         YES         1.7433         PASS(PPP)         1.6373           91         NO         5.5472         FALL (FFF)         3.5675           92         NO         10.103         FALL (FFF)         3.5675           93         NO         4.1235         FALL (FFF)         2.4266           94         NO         4.5434         FALL (FFF)         2.4266           94         NO         4.5434         FALL (FFF)         2.4933           95         NO         16.1346         FALL (FFF)         8.6433           96         NO         5.44443         FALL (FFF)         6.6433           97         NO         6.4636         FALL (FFF)         6.6433           98         YES         2.6643         PASS(PPP)         1.6217           100         NO         8.7603         FALL (FFF)         6.5458           102         NO         8.7603         FALL (FFF)         5.6559	87	NO	5.4124	FAIL (FFF)	3.6544
89         YES         2.1505         PASS(PP)         1.6373           90         YES         1.7433         PASS(PP)         1.4396           91         NO         5.5472         FAIL (FF)         1.4396           92         NO         10.103         FAIL (FF)         6.4322           93         NO         4.1235         FAIL (FF)         6.4322           93         NO         4.1235         FAIL (FF)         2.4266           94         NO         4.5434         FAIL (FF)         2.4933           95         NO         16.1346         FAIL (FF)         2.4933           96         NO         5.4443         FAIL (FF)         2.4933           97         NO         6.4636         FAIL (FF)         2.434           97         NO         6.4636         FAIL (FF)         2.908           98         YES         2.5643         PASL(PP)         1.9455           99         NO         7.8454         FAIL (FF)         6.1278           100         NO         8.8602         FAIL (FF)         6.5399           102         NO         8.9782         FAIL (FF)         6.6359           103	88	NO	5.5765	FAIL (FFF)	3.5643
90         YES         1.7433         PASS(PP)         1.4396           91         NO         5.5472         FAIL (FF)         3.5675           92         NO         10.103         FAIL (FF)         3.5675           93         NO         4.1235         FAIL (FF)         3.5675           94         NO         4.5434         FAIL (FF)         2.4266           94         NO         4.5434         FAIL (FF)         2.4266           95         NO         16.1346         FAIL (FF)         2.4266           96         NO         5.4443         FAIL (FF)         8.6433           97         NO         6.4636         FAIL (FF)         8.6433           97         NO         6.4636         FAIL (FF)         6.0434           97         NO         6.4636         FAIL (FF)         6.0434           100         NO         8.8766         FAIL (FF)         6.1278           101         NO         8.4763         FAIL (FF)         6.5488           102         NO         8.4703         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         6.5458           105 <td>89</td> <td>YES</td> <td>2.1505</td> <td>PASS(PPP)</td> <td>1.6373</td>	89	YES	2.1505	PASS(PPP)	1.6373
91         NO         5.5472         FAIL (FF)         5.5675           92         NO         10.103         FAIL (FF)         6.4322           93         NO         4.1235         FAIL (FF)         6.4322           93         NO         4.1235         FAIL (FF)         2.4266           94         NO         4.5434         FAIL (FF)         2.4266           95         NO         16.1346         FAIL (FF)         2.4933           96         NO         5.4443         FAIL (FF)         2.5434           97         NO         6.4636         FAIL (FF)         2.5434           98         YES         2.5643         PASC(PP)         1.9455           100         NO         8.8766         FAIL (FF)         6.1278           101         NO         9.8162         FAIL (FF)         6.1278           102         NO         8.4633         FAIL (FF)         6.1278           103         NO         8.4633         FAIL (FF)         6.1278           104         NO         8.3634         FAIL (FF)         6.1268           105         NO         8.3634         FAIL (FF)         1.672           106 <td>90</td> <td>YES</td> <td>1.7433</td> <td>PASS(PPP)</td> <td>1.4396</td>	90	YES	1.7433	PASS(PPP)	1.4396
92         NO         10.103         FAIL (FF)         6.4322           93         NO         4.1235         FAIL (FF)         2.4266           94         NO         4.5434         FAIL (FF)         2.4266           94         NO         4.5434         FAIL (FF)         2.4266           95         NO         16.1346         FAIL (FF)         8.6433           96         NO         5.4443         FAIL (FF)         8.6433           97         NO         6.4636         FAIL (FF)         2.9068           98         YES         2.5643         PASS(PP)         1.9455           99         NO         7.8454         FAIL (FF)         6.0943           100         NO         8.8766         FAIL (FF)         6.5488           102         NO         8.7603         FAIL (FF)         6.5488           102         NO         8.7603         FAIL (FF)         6.559           104         NO         19.3782         FAIL (FF)         6.559           104         NO         19.3782         FAIL (FF)         6.659           105         NO         8.4918         FAIL (FF)         6.6079           106 <td>91</td> <td>NO</td> <td>5.5472</td> <td>FAIL (FFF)</td> <td>3.5675</td>	91	NO	5.5472	FAIL (FFF)	3.5675
93         NO         4.1235         FAIL (FF)         2.4266           94         NO         4.5434         FAIL (FF)         2.4933           95         NO         16.1346         FAIL (FF)         2.4933           96         NO         5.4443         FAIL (FF)         2.5434           97         NO         6.4636         FAIL (FF)         2.5434           97         NO         6.4636         FAIL (FF)         2.5434           97         NO         6.4636         FAIL (FF)         2.5434           98         YES         2.5643         PASS(PP)         1.9455           100         NO         8.8766         FAIL (FF)         6.071           100         NO         8.8766         FAIL (FF)         6.1278           101         NO         9.8162         FAIL (FF)         6.559           102         NO         8.4638         FAIL (FF)         5.6559           103         NO         8.4639         FAIL (FF)         5.6559           106         NO         8.3634         FAIL (FF)         5.6559           106         NO         8.4018         FAIL (FF)         5.4769           107 <td>92</td> <td>NO</td> <td>10.103</td> <td>FAIL (FFF)</td> <td>6.4322</td>	92	NO	10.103	FAIL (FFF)	6.4322
94         NO         4.5434         FAIL (FF)         2.4933           95         NO         16.1346         FAIL (FF)         8.6433           96         NO         5.4443         FAIL (FF)         8.6433           97         NO         6.4636         FAIL (FF)         8.26433           97         NO         6.4636         FAIL (FF)         2.9068           98         YES         2.5643         PASS(PP)         1.9455           99         NO         7.8454         FAIL (FF)         6.0433           100         NO         8.8766         FAIL (FF)         6.6438           102         NO         8.7603         FAIL (FF)         6.5458           102         NO         8.7603         FAIL (FF)         6.559           104         NO         19.3782         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         6.079           105         NO         8.4583         FAIL (FF)         6.079           106         NO         8.4949         FAIL (FF)         6.079           107         YES         2.1404         PASS(PP)         1.5672           108 </td <td>93</td> <td>NO</td> <td>4.1235</td> <td>FAIL (FFF)</td> <td>2.4266</td>	93	NO	4.1235	FAIL (FFF)	2.4266
95         NO         16.1346         FAIL (FF)         8.6433           96         NO         5.4443         FAIL (FF)         2.5434           97         NO         6.4636         FAIL (FF)         2.5434           98         YES         2.5643         PASS(PP)         1.9455           99         NO         7.8454         FAIL (FF)         6.1278           100         NO         8.8766         FAIL (FF)         6.1278           101         NO         9.8162         FAIL (FF)         6.1278           102         NO         8.4633         FAIL (FF)         5.6559           103         NO         8.4633         FAIL (FF)         5.6559           104         NO         9.3782         FAIL (FF)         5.6559           105         NO         8.4018         FAIL (FF)         5.453           106         NO         8.3634         FAIL (FF)         5.473           106         NO         8.4018         FAIL (FF)         1.3654           106         NO         8.4018         FAIL (FF)         1.472           107 <yes< td="">         2.1404         PASS(PP)         1.620           108         YE</yes<>	94	NO	4.5434	FAIL (FFF)	2.4933
96         NO         5.4443         FAIL (FF)         2.5434           97         NO         6.4636         FAIL (FF)         2.9068           98         YES         2.5643         PASS(PP)         1.9455           99         NO         7.8454         FAIL (FF)         6.0433           100         NO         8.8766         FAIL (FF)         6.0433           101         NO         8.8766         FAIL (FF)         6.5458           102         NO         8.7603         FAIL (FF)         6.5458           102         NO         8.7603         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         6.079           105         NO         8.4594         FAIL (FF)         6.079           106         NO         8.4018         FAIL (FF)         6.079           107         YES         2.3044         PASS(PP)         1.5672           108         YES         2.4044         PASS(PP)         1.5672           109         YES         2.3044         PASS(PP)         1.5722           110	95	NO	16.1346	FAIL (FFF)	8.6433
97         NO         6.4636         FALL (FF)         2.968           98         YES         2.5643         PASS(PP)         1.9455           99         NO         7.8454         FALL (FF)         6.0943           100         NO         8.8766         FALL (FF)         6.1278           101         NO         9.8162         FALL (FF)         6.1278           102         NO         8.7635         FALL (FF)         6.5458           102         NO         8.4583         FALL (FF)         5.6559           104         NO         19.3782         FALL (FF)         6.0702           106         NO         8.4583         FALL (FF)         6.0702           106         NO         8.4584         FALL (FF)         6.0702           106         NO         8.4018         FALL (FF)         6.0702           107         YES         2.3040         PASS(PP)         1.5672           108         YES         2.3304         PASS(PP)         1.5672           109         YES         2.3404         PASS(PP)         1.572           110         NO         8.6743         FALL (FF)         5.3333           11	96	NO	5.4443	FAIL (FFF)	2.5434
96         YES         2.5643         PASS(PP)         1.9455           99         NO         7.8454         FAIL (FF)         6.0943           100         NO         8.8766         FAIL (FF)         6.0943           101         NO         9.8162         FAIL (FF)         6.5478           102         NO         8.7603         FAIL (FF)         6.5478           102         NO         8.7603         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         6.079           106         NO         8.4918         FAIL (FF)         6.079           106         NO         8.4918         FAIL (FF)         6.079           107         YES         2.3044         PASS(PP)         1.5672           108         YES         2.3404         PASS(PP)         1.5672           109         YES         2.3304         PASS(PP)         1.5672           110         NO         8.0493         FAIL (FF)         5.7333           112         NO         8.6743         FAIL (FF)         5.3202           1	97	NO	6.4636	FAIL (FFF)	2.9968
99         NO         7.8454         FAIL (FF)         6.043           100         NO         8.8766         FAIL (FF)         6.1278           101         NO         9.8162         FAIL (FF)         6.1278           102         NO         8.7603         FAIL (FF)         6.5458           103         NO         8.4583         FAIL (FF)         5.6559           104         NO         8.4583         FAIL (FF)         5.6559           105         NO         8.8594         FAIL (FF)         6.0079           106         NO         8.8594         FAIL (FF)         6.0070           106         NO         8.018         FAIL (FF)         6.0709           106         NO         8.0494         PAIS (PP)         1.6269           108         YES         2.3040         PASS (PP)         1.672           109         YES         2.3040         PASS (PP)         1.572           110         NO         8.0493         FAIL (FF)         5.7333           112         NO         8.6743         FAIL (FF)         5.7323           112         NO         8.0423         FAIL (FF)         3.3204           1	98	YES	2.5643	PASS(PPP)	1.9455
100         NO         8.8766         FAIL (FF)         6.1278           101         NO         9.8162         FAIL (FF)         6.3458           102         NO         8.7603         FAIL (FF)         6.5458           102         NO         8.7603         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         5.6579           105         NO         8.8594         FAIL (FF)         5.6079           106         NO         8.4018         FAIL (FF)         6.0079           107         YES         2.3041         PASS(PPP)         1.6269           108         YES         2.4049         PASS(PPP)         1.6269           108         YES         2.3304         PASS(PPP)         1.7872           100         NO         8.0493         FAIL (FF)         5.7333           111         NO         7.2592         FAIL (FF)         5.659           113         NO         9.2313         FAIL (FF)         3.334           112         NO         8.0423         FAIL (FF)         3.3340	99	NO	7.8454	FAIL (FFF)	6.0943
101         NO         9.8162         FAIL (FF)         6.5458           102         NO         8.7603         FAIL (FF)         5.6559           103         NO         8.4583         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         5.6559           105         NO         8.8594         FAIL (FF)         11.354           106         NO         8.8594         FAIL (FF)         6.079           106         NO         8.4018         FAIL (FF)         11.354           106         NO         8.4018         FAIL (FF)         1.3672           107         YES         2.3404         PASS(PPP)         1.6262           108         YES         2.3404         PASS(PPP)         1.7872           109         YES         2.3404         PASS(PPP)         1.7872           110         NO         8.0493         FAIL (FF)         5.7323           111         NO         7.2592         FAIL (FF)         5.7323           112         NO         8.0743         FAIL (FF)         3.3204           114         NO         7.1233         FAIL (FF)         3.3240	100	NO	8.8766	FAIL (FFF)	6.1278
102         NO         8,7603         FAIL (FF)         5,6559           103         NO         8,4583         FAIL (FF)         5,6559           104         NO         19,3782         FAIL (FF)         5,6559           105         NO         8,8594         FAIL (FF)         6,0079           106         NO         8,4018         FAIL (FF)         6,0079           106         NO         8,4018         FAIL (FF)         6,0079           107         YES         2,304         PASS(PPP)         1,6269           108         YES         2,404         PASS(PPP)         1,6269           109         YES         2,304         PASS(PPP)         1,7872           110         NO         8,0493         FAIL (FF)         6,0079           111         NO         7,2592         FAIL (FF)         5,7333           112         NO         8,6743         FAIL (FF)         5,7323           113         NO         7,233         FAIL (FF)         3,3346           115         NO         8,0423         FAIL (FF)         3,3340           116         NO         8,0425         FAIL (FF)         5,5459 <t< td=""><td>101</td><td>NO</td><td>9.8162</td><td>FAIL (FFF)</td><td>6.5458</td></t<>	101	NO	9.8162	FAIL (FFF)	6.5458
103         NO         8.4583         FAIL (FF)         5.6559           104         NO         19.3782         FAIL (FF)         11.3654           105         NO         8.8594         FAIL (FF)         11.3654           106         NO         8.4018         FAIL (FF)         6.0079           106         NO         8.4018         FAIL (FF)         5.4739           107         YES         2.3404         PASS(PPP)         1.6364           108         YES         2.1404         PASS(PP)         1.6362           109         YES         2.3404         PASS(PP)         1.7872           109         YES         2.3404         PASS(PP)         1.7872           109         YES         2.3404         PASS(PP)         1.7872           110         NO         8.0493         FAIL (FF)         5.7323           111         NO         7.2592         FAIL (FF)         5.7323           112         NO         8.0743         FAIL (FF)         5.3202           113         NO         7.21233         FAIL (FF)         3.3204           115         NO         8.0428         FAIL (FF)         5.5459	102	NO	8,7603	FAIL (FFF)	5.6559
104         NO         19.3782         FAIL (FF)         11.3654           105         NO         8.8594         FAIL (FF)         6.0079           106         NO         8.4018         FAIL (FF)         6.0079           106         NO         8.4018         FAIL (FF)         6.0079           107         YES         2.3044         PASS(PP)         1.6269           108         YES         2.1404         PASS(PP)         1.6269           109         YES         2.3304         PASS(PP)         1.7872           110         NO         8.0493         FAIL (FF)         6.0079           111         NO         8.0493         FAIL (FF)         5.7333           112         NO         8.6743         FAIL (FF)         5.6066           113         NO         7.233         FAIL (FF)         3.3346           114         NO         7.1233         FAIL (FF)         3.3340           116         NO         8.0428         FAIL (FF)         5.5459           117         NO         8.0428         FAIL (FF)         5.3304	103	NO	8.4583	FAIL (FFF)	5.6559
105         NO         8.8594         FAIL (FF)         6.0079           106         NO         8.4018         FAIL (FF)         5.4739           107         YES         2.3404         PASS(PP)         1.6309           108         YES         2.1404         PASS(PP)         1.6302           108         YES         2.3404         PASS(PP)         1.5672           109         YES         2.3404         PASS(PP)         1.7872           110         NO         8.0493         FAIL (FF)         5.7323           111         NO         8.0493         FAIL (FF)         5.7323           112         NO         8.6743         FAIL (FF)         5.7323           113         NO         9.2213         FAIL (FF)         3.3246           115         NO         8.0428         FAIL (FF)         3.3202           116         NO         8.0428         FAIL (FF)         5.5459           117         NO         8.0428         FAIL (FF)         5.3204	104	NO	19.3782	FAIL (FFF)	11.3654
106         NO         8.4018         FAIL (FF)         5.4739           107         YES         2.3404         PASS(PP)         1.6269           108         YES         2.1404         PASS(PP)         1.6269           109         YES         2.3304         PASS(PP)         1.5672           109         YES         2.3304         PASS(PP)         1.7872           110         NO         8.0493         FAIL (FF)         5.7333           111         NO         8.6743         FAIL (FF)         6.6666           113         NO         9.2313         FAIL (FF)         5.3202           114         NO         7.1233         FAIL (FF)         3.3346           115         NO         8.0428         FAIL (FF)         5.3499           116         NO         8.0428         FAIL (FF)         5.3499           117         NO         8.0428         FAIL (FF)         3.3204	105	NO	8.8594	FAIL (FFF)	6.0079
107         YES         2.3404         PASS(PP)         1.6269           108         YES         2.1404         PASS(PP)         1.5672           109         YES         2.3304         PASS(PP)         1.5672           110         NO         8.0493         FAIL (FF)         4.6424           111         NO         8.0493         FAIL (FF)         5.7323           112         NO         8.6743         FAIL (FF)         5.7323           113         NO         9.5213         FAIL (FF)         5.7223           114         NO         7.1233         FAIL (FF)         3.3246           115         NO         8.0428         FAIL (FF)         5.5459           116         NO         8.0428         FAIL (FF)         5.5459           117         NO         8.0428         FAIL (FF)         5.3204	106	NO	8.4018	FAIL (FFF)	5.4739
108         YES         2.1404         PASS(PP)         1.5672           109         YES         2.3304         PASS(PP)         1.7872           110         NO         8.0493         FALL (FF)         1.7872           111         NO         8.0493         FALL (FF)         5.7323           112         NO         8.6743         FALL (FF)         5.7323           113         NO         9.2313         FALL (FF)         5.7223           114         NO         7.1233         FALL (FF)         3.3346           115         NO         8.0423         FALL (FF)         3.3202           116         NO         8.0425         FALL (FF)         5.5459           117         NO         8.0425         FALL (FF)         3.3204	107	YES	2.3404	PASS(PPP)	1.6269
109         YES         2.3304         PASS(PP)         1.7872           110         NO         8.0493         FAIL (FF)         4.6124           111         NO         7.2592         FAIL (FF)         4.6124           111         NO         8.0743         FAIL (FF)         6.6666           112         NO         8.0743         FAIL (FF)         5.7323           113         NO         9.3213         FAIL (FF)         7.2223           114         NO         7.1233         FAIL (FF)         3.3246           115         NO         8.0428         FAIL (FF)         3.3202           116         NO         8.0428         FAIL (FF)         5.5459           117         NO         8.0428         FAIL (FF)         3.3204	108	YES	2.1404	PASS(PPP)	1.5672
110         NO         8.0493         FAIL (FF)         4.6424           111         NO         7.2592         FAIL (FF)         5.7323           112         NO         8.6743         FAIL (FF)         5.7323           113         NO         9.2213         FAIL (FF)         5.7223           114         NO         7.1233         FAIL (FF)         7.2223           114         NO         7.1233         FAIL (FF)         3.3246           115         NO         8.0428         FAIL (FF)         3.3202           116         NO         8.0428         FAIL (FF)         5.5459           117         NO         8.0428         FAIL (FF)         5.3304	109	YES	2.3304	PASS(PPP)	1.7872
111         NO         7.2592         FAIL (FF)         5.7323           112         NO         8.6743         FAIL (FF)         6.6666           113         NO         9.3213         FAIL (FF)         7.2233           114         NO         7.1233         FAIL (FF)         7.2233           115         NO         8.0428         FAIL (FF)         3.3240           116         NO         8.8162         FAIL (FF)         5.5459           117         NO         8.0428         FAIL (FF)         5.3202	110	NO	8.0493	FAIL (FFF)	4.6424
112         NO         8.6743         FAIL (FF)         6.6666           113         NO         9.213         FAIL (FF)         7.223           114         NO         7.1233         FAIL (FF)         7.223           114         NO         7.1233         FAIL (FF)         3.324           115         NO         8.0428         FAIL (FF)         3.3202           116         NO         8.0428         FAIL (FF)         5.5459           117         NO         8.0428         FAIL (FF)         3.3204	111	NO	7.2592	FAIL (FFF)	5.7323
113         NO         9.3213         FAIL (FF)         7.2223           114         NO         7.1233         FAIL (FF)         3.246           115         NO         8.0428         FAIL (FF)         3.3202           116         NO         8.0428         FAIL (FF)         5.5459           117         NO         8.0428         FAIL (FF)         5.3204	112	NO	8.6743	FAIL (FFF)	6.6666
114         NO         7.1233         FAIL (FFF)         3.3246           115         NO         8.0428         FAIL (FFF)         3.3202           116         NO         8.8162         FAIL (FFF)         5.5459           117         NO         8.0428         FAIL (FFF)         3.3204	113	NO	9.3213	FAIL (FFF)	7.2223
115         NO         8.0428         FAIL (FFF)         3.3202           116         NO         8.8162         FAIL (FFF)         5.5459           117         NO         8.0428         FAIL (FFF)         3.3204	114	NO	7 1233	FAIL (FFF)	3 3246
116 NO 8.8162 FAIL (FFF) 5.5459 117 NO 8.0428 FAIL (FFF) 3.3204	115	NO	8.0428	FAIL (FFF)	3.3202
117 NO 8.0428 FAIL (FFF) 3.3204	116	NO	8.8162	FAIL (FFF)	5.5459
	117	NO	8.0428	FAIL (FFF)	3.3204

Table 7. Performance of PCA (77 test signals)

Classifier	Specificity(%)	Sensitivity( % )	Accuracy (%)
PCA	100	83.8	92.2

As seen from the performance tables of PCA analysis, it is found that the sensitivity is 83.8% in case of PCA. PCA analysis play important role when biochemical composition of subject is considered [8].

In case of pathology test spectra used for prediction against normal calibration set, it is seen that there were few pathology spectra, which were classified, as normal. This deviation may be due to the recording of the spectra from normal site of patient.

## **VI. ACKNOWLEDGMENT**

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