IJCSC 0973-7391 Vol 6 • Number 2 April - Sep 2015 pp. 92-101 **Impact Factor: 2.5** **Available at www.csjournals.com**

Optimal Feature Selection for Accelerated Plethysmography based Enhanced Pitta Classification

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Abstract: The theory of Ayurveda evolved from the deep understanding of creation.According to Ayurveda, health is a perpetual and a participatory process that include all aspects of life and is dependent on three body constituents: Vata, Pitta and Kapha. In our study we have analyzed AcceleratedPlethysmography to find out the features that may directly link to enhanced level of Pitta. Our focus of research is to optimally select those features that may give high accuracy of enhanced Pitta level detection.

Keywords- Photo Plethysmography (PPG), Accelerated Plethysmography (APG), Fisher Discriminant Ratio (FDR), Correlation.

INTRODUCTION

Ayurveda means Science of life or living sensibly on the basis of knowledge. Human health is dependent on three body constituents known as Doshas:Vata, Pitta and Kapha. These constituents have a physical, mental and spiritual impact on the human body. As long as these three constituents are properly balanced, the human is healthy. Increase in any one constituent at the cost of others results in disease. In this study, the focus is being made on detecting enhanced Pitta dosha. Pitta level increases naturally during the middle of digestion, middle of the day or during the middle of life[1].

For this purpose of detecting high Pitta level,finger pulse profile of Photoplethysmography (PPG)is analyzed and certain features are selected. Photoplethysmography is an optical technique that detects variations in the volume of blood in the microvascular bed of tissue [2-3].The second derivative of the primary PPG is derived to obtain AcceleratedPlethysmography (APG) as shown in Figure 1.APG stabilizes the baseline and separates the components of the waveform more clearly as compared to the first derivative[4].

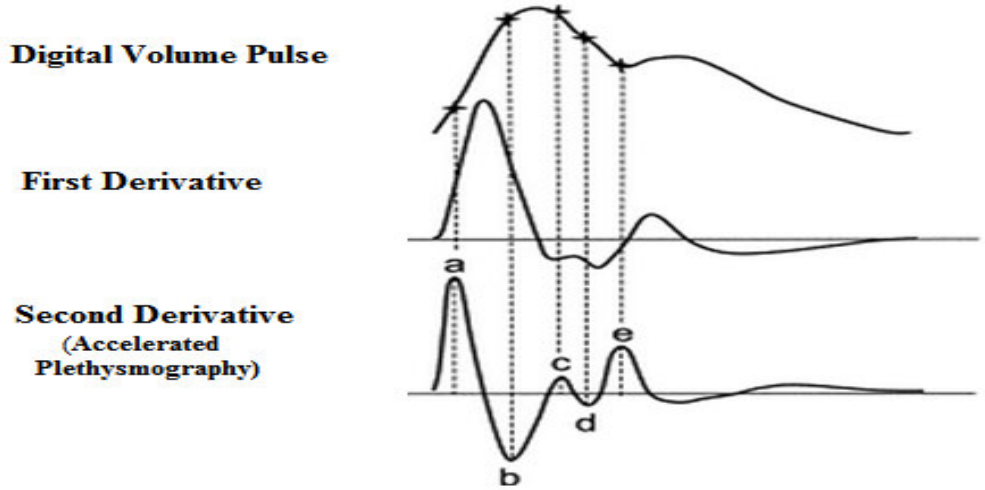

Figure 1- A PPG signal,its first and second derivative [5]

Many researchers use questionnaires to detect this imbalance in AyurvedicDoshas[6-9]. Also it has been established that every finger of a given subject has a unique pulse profile asautocorrelation for a given finger of subject is always higher than correlation with corresponding finger of any othersubject [10-11]. The present research work has made use of data acquired fromboth left and right hands of the three fingers (index,middle and ring).This data has been acquired after breakfast,before lunch and after lunch for determination of the AyurvedicDoshaand is documented in Post graduate thesis titled “Automatic Feature Extraction in Accelerated Plethysmography” [12].

PROBLEM DEFINITION

According to Ayurveda, Pitta level in thenormal healthy human body increases during mid-day and after taking meals. Increase in Pitta otherwise may be due to some disease. This study is being conducted with a motive of finding features that may directly link to the enhanced level of Pitta.For this purpose certain features extracted from the second derivative of PPG may be used. Ourfocus of research is to optimally select those features which may give high accuracy of enhanced Pitta level detection.

METHOD

An MP150 System and Acknowledge software was used to record the data fromindex,middle and ring fingers of both the hands for 25 healthy subjects.The PPG was acquired for a given subject on the same day at three different instances-

(i) **Class A**-One and a half hour after breakfast but before 10:30 am. The early part of the day ensures lower Pitta level while one and a half hour delay after taking meals subdues enhanced Pitta on account of meal digestion.

(ii)**Class B**-Immediately before lunch provided lunch is taken between 1-2 pm.The mid-day usually enhances Pitta level.

(iii) **Class C**-Fifteen minutes after lunch.Again mid-day ensures higher Pitta level,while taking meals also helps in maintaining high Pitta level and it enhances it further [13].

The second derivative of PPG was taken to extractdistinctive peaks of the waveform: a,b,c,d and e as shown in Figure 1.The amplitude ratios b/a,c/a,d/a and e/a were calculated.Further average and standard deviation of each ratio was obtained.Thus a total of 8 features were obtained for each finger.Since the data was acquired from six fingers, we have a total of 48 features for each subject.In early research, thesefeatures were extractedmanually[14-18].Recently an advancement has been made and features are extracted using a computer algorithm[19].For the sake of convenience, we shall refer to these set of 48 features as **"Gross Feature Set".**

The data so acquired is processed for selecting optimal features for enhanced Pitta detection.For this purpose, the data has been divided into three ComparativeGroups namely: ComparativeGroup1of After Breakfast (Class A) and Before Lunch (Class B), ComparativeGroup2 of After breakfast (Class A) and After lunch (Class C) and ComparativeGroup3 of Before Lunch (Class B) and After Lunch (Class C).

HYPOTHESIS

(i)Pitta increases appreciably for Comparative Group 1 i.e. After breakfast (Class A) and Before lunch (Class B).
(ii) Pitta increases appreciably for Comparative Group 2 i.e. After breakfast (Class A) and After lunch (Class C).
(iii) Pitta increases slightly for Comparative Group 3 i.e. Before lunch (Class B) and After lunch (Class C).

REDUCTION INFEATURE SET USING FISHER LINEAR DISCRIMINANT ANALYSIS

For the three Comparative Groups,detection of enhanced Pitta can be done using 48 extracted features of APG. To optimally select the smallest number of features for each Comparative group we have employed Fisher Discriminant Ratio (FDR).

Fisher linear discriminant analysisis a widely-used technique for pattern classification and finds a linear discriminant that yields optimal discrimination between two classes [20].The value of FDR is given as,

$$FDR = \frac{|\mu_1 - \mu_2|}{\sqrt{\sigma_1^2 + \sigma_2^{\,2}}} \quad \text{.....(i)}$$

Here σ is the standard deviation, μ is the average and the subscript represents the two classes.Fisher discriminant ratio for all the three Comparativegroups is arranged in a descending order and those features which have FDR ratio above the defined threshold i.e. '0.25' are selected.

FDR of Comparative Group 1 i.e. After Breakfast (Class A) and Before Lunch (Class B) is shown below in Table 1. Out of a total of 48 features i.e. "Gross Feature Set", the highlighted portion indicates the 17 features that have FDR above the threshold value '0.25' and these features are referred to as the "**Truncated Feature Set**".

Table 1: Feature selection usingFisher Discriminant Ratio (ComparativeGroup 1)

S.NO	**FEATURES**	**FDR VALUE**
1	LEFT INDEX e/a AVERAGE	0.485540668
2	RIGHT MIDDLE e/a AVERAGE	0.388081853
3	LEFT RING b/a AVERAGE	0.38513289
4	RIGHT INDEX d/a AVERAGE	0.349564697
5	RIGHT MIDDLE d/a AVERAGE	0.34447214
6	RIGHT RING b/a STANDARD DEVIATION	0.339491678
7	RIGHT INDEX b/a STANDARD DEVIATION	0.329570973
8	LEFT INDEX b/a AVERAGE	0.323443261
9	RIGHT RING d/a STANDARD DEVIATION	0.304748162
10	RIGHT RING e/a STANDARD DEVIATION	0.295245403
11	LEFT INDEX d/a STANDARD DEVIATION	0.285547823
12	RIGHT INDEX e/a STANDARD DEVIATION	0.28252309
13	RIGHT MIDDLE d/a STANDARD DEVIATION	0.266119946
14	LEFT INDEX d/a AVERAGE	0.261269716
15	RIGHT MIDDLE e/a STANDARD DEVIATION	0.257547542
16	LEFT MIDDLE c/a AVERAGE	0.254284819
17	RIGHT INDEX c/a STANDARD DEVIATION	0.249709265
18	LEFT MIDDLE d/a AVERAGE	0.242835192
19	LEFT RING d/a AVERAGE	0.2252015
20	RIGHT INDEX d/a STANDARD DEVIATION	0.223197182
21	RIGHT RING d/a AVERAGE	0.222401213
22	RIGHT MIDDLE c/a STANDARD DEVIATION	0.203795798
23	RIGHT MIDDLE b/a STANDARD DEVIATION	0.203700172
24	RIGHT INDEX c/a AVERAGE	0.184903361
25	RIGHT INDEX e/a AVERAGE	0.173166284
26	LEFT MIDDLE e/a STANDARD DEVIATION	0.160832503
27	LEFT MIDDLE c/a STANDARD DEVIATION	0.158693257
28	RIGHT RING b/a AVERAGE	0.158094588
29	RIGHT MIDDLE c/a AVERAGE	0.15478553
30	LEFT INDEX e/a STANDARD DEVIATION	0.153762373
31	LEFT INDEX c/a STANDARD DEVIATION	0.146298243
32	RIGHT INDEX b/a AVERAGE	0.140509813
33	LEFT MIDDLE d/a STANDARD DEVIATION	0.139464934
34	LEFT RING d/a STANDARD DEVIATION	0.12641301
35	RIGHT RING c/a STANDARD DEVIATION	0.122199424
36	RIGHT MIDDLE b/a AVERAGE	0.106500236
37	LEFT MIDDLE b/a AVERAGE	0.098607982
38	RIGHT RING e/a AVERAGE	0.08451596
39	LEFT RING e/a AVERAGE	0.08213197
40	LEFT RING c/a AVERAGE	0.079521212
41	LEFT RING c/a STANDARD DEVIATION	0.079356719
42	LEFT INDEX b/a STANDARD DEVIATION	0.07632933
43	LEFT RING b/a STANDARD DEVIATION	0.072563243
44	LEFT RING e/a STANDARD DEVIATION	0.035008898
45	LEFT INDEX c/a AVERAGE	0.019502961
46	LEFT MIDDLE b/a STANDARD DEVIATION	0.016101735
47	RIGHT RING c/a AVERAGE	0.009127493
48	LEFT MIDDLE e/a AVERAGE	0.00811542

#The features selected are highlighted.

Fisher discriminant ratio of ComparativeGroup 2 i.e.After breakfast (Class A) and After lunch (Class C) is summarizedbelow in Table 2. From "Gross Feature Set",18 features having fisher discriminant ratio above '0.25' have been selected. This **"Truncated Feature Set"**of 18 features is considered for further analysis.

Table 2: Feature selection using Fisher Discriminant Ratio (ComparativeGroup 2)

S.NO	FEATURES	FDR VALUE
1	LEFT MIDDLE d/a STANARD DEVIATION	0.43154904
2	LEFT MIDDLE b/a STANDARD DEVIATION	0.416672613
3	LEFT MIDDLE e/a STANDARD DEVIATION	0.404427618
4	LEFT INDEX d/a AVERAGE	0.338085848
5	RIGHT RING e/a STANDARD DEVIATION	0.336539478
6	RIGHT INDEX b/a AVERAGE	0.327794377
7	LEFT RING d/a AVERAGE	0.312003219
8	RIGHT INDEX b/a STANDARD DEVIATION	0.310400067
9	RIGHT RING b/a AVERAGE	0.308010964
10	LEFT RING e/a AVERAGE	0.306157011
11	RIGHT RING d/a AVERAGE	0.297259497
12	RIGHT MIDDLE e/a STANDARD DEVIATION	0.296454759
13	LEFT INDEX c/a STANDARD DEVIATION	0.296178405
14	LEFT RING c/a STANDARD DEVIATION	0.276053601
15	LEFT MIDDLE c/a STANDARD DEVIATION	0.274148472
16	RIGHT MIDDLE b/a AVERAGE	0.271858207
17	RIGHT INDEX c/a AVERAGE	0.253260108
18	LEFT MIDDLE d/a AVERAGE	0.252925157
19	LEFT INDEX d/a STANDARD DEVIATION	0.23009828
20	LEFT RING b/a AVERAGE	0.229535601
21	LEFT RING e/a STANDARD DEVIATION	0.217640114
22	RIGHT MIDDLE d/a AVERAGE	0.19626043
23	LEFT INDEX b/a STANDARD DEVIATION	0.19493547
24	RIGHT MIDDLE b/a STANDARD DEVIATION	0.193815811
25	LEFT MIDDLE e/a AVERAGE	0.188646499
26	RIGHT RING b/a STANDARD DEVIATION	0.185018002
27	LEFT RING b/a STANDARD DEVIATION	0.183427953
28	RIGHT MIDDLE c/a AVERAGE	0.164838647
29	LEFT MIDDLE b/a AVERAGE	0.161065448
30	RIGHT MIDDLE e/a AVERAGE	0.132672492
31	RIGHT MIDDLE d/a STANDARD DEVIATION	0.122061308
32	LEFT RING c/a AVERAGE	0.098458169
33	RIGHT RING c/a AVERAGE	0.095583867
34	LEFT INDEX e/a STANDARD DEVIATION	0.093824833
35	RIGHT INDEX d/a STANDARD DEVIATION	0.068214163
36	RIGHT INDEX d/a AVERAGE	0.068125337
37	RIGHT RING c/a STANDARD DEVIATION	0.067069265
38	LEFT RING d/a STANDARD DEVIATION	0.063243873
39	RIGHT MIDDLE c/a STANDARD DEVIATION	0.061978282
40	RIGHT RING d/a STANDARD DEVIATION	0.056271453
41	LEFT INDEX e/a AVERAGE	0.053551454
42	LEFT MIDDLE c/a AVERAGE	0.031814104
43	RIGHTINDEX e/a STANDARD DEVIATION	0.030889449
44	LEFT INDEX b/a AVERAGE	0.018778868
45	RIGHT INDEX e/a AVERAGE	0.01024219
46	RIGHT INDEX c/a STANDARD DEVIATION	0.006230603
47	LEFT INDEX c/a AVERAGE	0.001945723
48	RIGHT RING e/a AVERAGE	0.00058241

#The features selected are highlighted.

Fisher discriminant ratio ofComparative Group 3i.e. Before lunch (Class B) and After lunch (Class C) is shown below in Table 3.Out of total 48 features, 18 features having fisher discriminant ratio above 0.25 have been selected. The 48 features represent the "Gross Feature Set" and the highlighted 18 features represent the**"Truncated Feature Set"**.

Table 3: Feature selection using Fisher Discriminant Ratio (ComparativeGroup 3)

S.NO	FEATURES	FDR VALUE
1	LEFT INDEX d/a AVERAGE	0.557494638
2	LEFT RING d/a AVERAGE	0.51046367
3	RIGHT INDEX b/a AVERAGE	0.48464012
4	RIGHT RING d/a AVERAGE	0.477976282
5	RIGHT MIDDLE d/a AVERAGE	0.470670476
6	LEFT MIDDLE d/a AVERAGE	0.4474165
7	LEFT INDEX e/a AVERAGE	0.446649895
8	LEFT MIDDLE b/a STANDARD DEVIATION	0.404636742
9	RIGHT MIDDLE b/a AVERAGE	0.399124209
10	RIGHT INDEX d/a AVERAGE	0.384797748
11	LEFT INDEX d/a STANDARD DEVIATION	0.379325084
12	LEFT MIDDLE d/a STANDARD DEVIATION	0.361774591
13	LEFT INDEX c/a STANDARD DEVIATION	0.353952096
14	RIGHT INDEX d/a STANDARD DEVIATION	0.289303038
15	LEFT MIDDLE e/a STANDARD DEVIATION	0.287046195
16	RIGHT RING d/a STANDARD DEVIATION	0.266290367
17	RIGHT INDEX c/a STANDARD DEVIATION	0.251379439
18	RIGHT MIDDLE c/a STANDARD DEVIATION	0.245837624
19	RIGHT INDEX e/a STANDARD DEVIATION	0.232513464
20	LEFT RING e/a AVERAGE	0.21938762
21	RIGHT RING b/a STANDARD DEVIATION	0.211815021
22	RIGHT MIDDLE d/a STANDARD DEVIATION	0.2062529
23	LEFT RING c/a STANDARD DEVIATION	0.205916869
24	LEFT MIDDLE c/a AVERAGE	0.2034347
25	LEFT MIDDLE c/a STANDARD DEVIATION	0.201324425
26	LEFT MIDDLE e/a AVERAGE	0.1961526
27	LEFT RING b/a AVERAGE	0.186118637
28	LEFT RING e/a STANDARD DEVIATION	0.172466289
29	LEFT RING b/a STANDARD DEVIATION	0.163652908
30	LEFT RING d/a STANDARD DEVIATION	0.160553312
31	RIGHT INDEX e/a AVERAGE	0.149608892
32	RIGHT MIDDLE e/a AVERAGE	0.133032306
33	RIGHT RING e/a STANDARD DEVIATION	0.11512928
34	LEFT INDEX b/a AVERAGE	0.099117588
35	RIGHT RING c/a AVERAGE	0.091537371
36	RIGHT INDEX c/a AVERAGE	0.078056978
37	RIGHT INDEX b/a STANDARD DEVIATION	0.071286412
38	RIGHT MIDDLE c/a AVERAGE	0.069389691
39	LEFT MIDDLE b/a AVERAGE	0.06567369
40	RIGHT RING e/a AVERAGE	0.061981437
41	RIGHT MIDDLE e/a STANDARD DEVIATION	0.058210431
42	LEFT INDEX b/a STANDARD DEVIATION	0.039579349
43	LEFT INDEX c/a AVERAGE	0.025365308
44	RIGHT RING c/a STANDARD DEVIATION	0.024710639
45	LEFT INDEX e/a STANDARD DEVIATION	0.018679264
46	RIGHT MIDDLE b/a STANDARD DEVIATION	0.018036483
47	LEFT RING c/a AVERAGE	0.017969417
48	RIGHT RING b/a AVERAGE	0.01787147

#The features selected are highlighted.

FURTHER REDUCTION IN FEATURE SET USING CORRELATION

The "Truncated Feature Set" obtained after fisher discriminant analysis is further correlated with each other to optimally reduce the number of features for furtheranalysis.Correlation is a statistical measure that specifies the extent to which two or more variables vary together. A positive correlation specify the extent to which these variables increase or decrease in parallel; a negative correlation specify the extent to which one variable increases as the other decreases.A correlation matrix is obtained for each group.Different threshold values are being set for optimal parameter reduction.

Taking Correlation Threshold Value as '0.6'

Firstly,a threshold value of '0.6' for correlation is being set and feature pairs having correlation above this threshold are selected.From the selected pair of features, the feature having lower FDR is discarded.All other features having lower correlation are also selected.The correlation matrix obtained in Comparative Group 1 is summarized in Table 4. From a total of 17 features in "Truncated Feature Set", 12features are shortlisted for further analysis.

Table 4: Feature selection using Correlation matrix (ComparativeGroup 1)

S.NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1																
2	0.78519	1															
3	0.032765	-0.18193	1														
4	0.246365	0.358479	0.24162	1													
5	0.264326	0.489834	0.277949	0.856412	1												
6	-0.10557	0.054748	0.230998	0.499212	0.455004	1											
7	0.044202	0.269801	-0.23386	-0.02993	0.221539	-0.01887	1										
8	0.155566	0.057281	-0.04033	-0.54416	-0.28774	-0.5081	0.164722	1									
9	-0.18356	-0.28219	0.099856	-0.1942	-0.1811	0.084789	-0.10732	-0.10251	1								
10	-0.31226	-0.174	-0.04248	-0.09238	-0.0632	0.377195	0.120103	-0.13494	0.634626	1							
11	0.062691	0.010087	0.16274	-0.38413	-0.21599	-0.26226	0.288793	0.359871	0.107074	0.116093	1						
12	-0.07571	-0.24287	0.526719	-0.18487	-0.13048	-0.09057	0.021046	0.270063	0.366271	0.204614	0.431978	1					
13	-0.09863	-0.02119	-0.27652	-0.20317	-0.10894	-0.09397	0.236812	0.356759	0.214473	0.341443	0.374904	0.257291	1				
14	0.318911	0.38481	0.077364	0.556382	0.592645	0.307372	0.285394	-0.1527	-0.11636	-0.04812	0.056159	-0.20051	-0.0871	1			
15	-0.13003	0.066323	-0.44224	-0.14653	-0.141129	-0.00142	0.2983333	0.127856	0.178263	0.415135	0.192935	0.140409	0.7368	-0.05006	1		
16	-0.13956	-0.32052	0.350504	0.333828	0.144613	0.380266	-0.34724	-0.5049	-0.05387	0.087982	-0.323	-0.21975	-0.25963	0.234939	-0.30516	1	
17	-0.39644	-0.43065	0.175117	-0.1211	-0.10247	0.182688	0.023953	0.097274	0.254967	0.141848	0.261668	0.576538	0.258073	-0.11772	0.108715	-0.20463	1

The following 12 features are referred to as "Reduced Feature Set" and these features might link to the enhanced pitta level. Table 5 represents the **"Reduced Feature Set"**.

Table 5: Reduced Feature Set (Comparative Group 1)

S.NO	Features
1	Left index e/a average
2	Left ring b/a average
3	Right index d/a average
4	Right ring b/a standard deviation
5	Right index b/a standard deviation
6	Left index b/a average
7	Right ring d/a standard deviation
8	Left index d/a standard deviation
9	Right index e/a standard deviation
10	Right middle d/a standard deviation
11	Left middle c/a average
12	Right index c/a standard deviation

Similarly, correlation between 18 features selected from the Comparative Group 2 is found and certain features are discarded.The matrix obtained is shown in the Table 6. The "Reduced Feature Set" of Comparative Group 2 is given in Table 7.

Table 6: Feature selection using Correlation matrix (ComparativeGroup 2)

S.NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1																	
2	0.527474	1																
3	0.946451	0.04269	1															
4	-0.08239	0.0332	-0.09113	1														
5	0.31008	-0.02878	0.29724	-0.01684	1													
6	-0.25524	-0.39227	-0.24086	-0.04014	-0.37813	1												
7	-0.14557	0.20756	-0.11609	0.72871	-0.33185	0.05943	1											
8	-0.04852	0.33903	0.04731	0.22678	0.1201	-0.13941	0.19369	1										
9	-0.04718	-0.06867	-0.08271	-0.15852	-0.3741	0.18466	-0.02456	-0.06523	1									
10	-0.09655	-0.02046	-0.01635	0.22165	-0.19532	-0.26602	0.48488	0.03434	0.33191	1								
11	0.1679	-0.04148	0.11111	0.4203	-0.25436	0.00217	0.23002	-0.25981	0.21438	0.01944	1							
12	0.15882	-0.00024	0.10219	0.01664	0.59427	-0.37921	-0.17002	0.39682	-0.11735	-0.12769	-0.04019	1						
13	-0.09504	0.019757	-0.13393	-0.31127	-0.12962	-0.07047	0.047475	0.07056	0.32649	-0.03239	-0.33152	0.05331	1					
14	-0.00246	-0.21243	-0.04784	-0.00894	0.08006	-0.11008	-0.10417	-0.0727	-0.28629	-0.154	0.29814	0.08813	-0.1314	1				
15	0.82628	0.56321	0.85144	-0.14477	0.16192	-0.25737	-0.07692	0.0917	-0.14703	0.00794	-0.01433	0.13424	-0.08931	0.03991	1			
16	-0.32546	-0.26102	-0.38709	0.11013	-0.42545	0.5647	-0.07423	0.09759	0.12901	-0.35229	0.16507	-0.34845	-0.23081	-0.08591	-0.32518	1		
17	-0.09389	-0.21782	-0.10789	0.31042	-0.22029	0.63887	0.36414	-0.12398	0.07959	0.03094	0.11879	-0.45232	-0.24159	-0.07049	-0.05081	0.53424	1	
18	0.16443	0.25855	0.15102	0.79159	-0.07595	-0.1303	0.76449	0.21874	-0.11124	0.21758	0.42605	0.05283	-0.05201	-0.11845	0.14334	-0.01955	0.28212	1

Table 7: Reduced Feature Set (Comparative Group 2)

S.NO	Features
1	Left middle d/a standard deviation
2	Left middle b/a standard deviation
3	Left index d/a average
4	Right ring e/a standard deviation
5	Right index b/a average
6	Right index b/a standard deviation
7	Right ring b/a average
8	Left ring e/a average
9	Right ring d/a average
10	Left index c/a standard deviation
11	Left ring c/a standard deviation
12	Right middle b/a average

Similarly, correlation between 18 features selected from the Comparative Group 3 is found and certain features are discarded. The matrix obtained is shown in the Table 8. The **"Reduced Feature Set"** of Comparative Group 3 is given in Table 9.

Table 8:Correlation matrix (ComparativeGroup 3)

S.NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1																	
2	0.544641	1																
3	-0.15653	-0.06538	1															
4	0.450479	0.769838	-0.38664	1														
5	0.378331	0.48873	-0.41134	0.717578	1													
6	0.596108	0.676095	-0.29882	0.634251	0.699717	1												
7	0.490032	0.257773	-0.15224	0.216234	0.017527	-0.007	1											
8	-0.03824	0.198495	-0.06865	0.149546	0.368639	0.11274	0.083996	1										
9	-0.06475	0.181229	0.472377	-0.27593	-0.4429	-0.21719	0.223673	0.08319	1									
10	0.41616	0.57531	-0.22755	0.731733	0.852922	0.680817	-0.02917	0.04399	-0.43406	1								
11	0.404182	-0.0898	-0.33875	-0.17349	-0.07978	0.287642	-0.03427	-0.25123	-0.09244	-0.10718	1							
12	-0.19864	0.021773	-0.15261	0.275672	0.627349	0.294106	-0.26257	0.42329	-0.25981	0.408182	-0.14557	1						
13	0.18282	-0.19035	-0.22763	-0.29495	-0.16011	0.113899	-0.10451	-0.27417	-0.04582	-0.23841	0.785712	-0.076695	1					
14	-0.03843	-0.13363	-0.05443	-0.04292	-0.34004	-0.28825	-0.01756	-0.07171	0.026035	-0.32618	0.370932	-0.050092	0.374274	1				
15	-0.21282	-0.0881	-0.07154	-0.02955	0.298708	-0.10321	-0.02057	0.57377	0.035793	-0.04274	-0.19223	0.614327	-0.080112	-0.01233	1			
16	-0.11651	-0.0296	-0.15247	0.04046	-0.17911	-0.2968	0.250706	0.01462	0.083516	-0.23113	-0.0285	-0.046393	0.184013	0.660853	0.121332	1		
17	0.064746	-0.1627	-0.06503	-0.07991	-0.18032	-0.15698	-0.08178	-0.04497	-0.09841	-0.27237	0.328701	-0.003644	0.484517	0.812965	0.134229	0.546609	1	
18	-0.097	-0.22335	-0.18864	-0.06957	0.26579	0.007437	-0.26693	0.50701	-0.21732	-0.10261	0.044596	0.450415	0.151046	0.19408	0.621426	0.051092	0.53483	1

Table 9: Reduced Feature Set (Comparative Group 3)

S.NO	Features
1	Left index d/a average
2	Left ring d/a average
3	Right index b/a average
4	Left index e/a average
5	Left middle b/a standard deviation
6	Right middle b/a average
7	Left index d/a standard deviation
8	Left index c/a standard deviation
9	Right index d/a standard deviation

Taking Correlation Threshold Value as '0.4'

When the threshold value of 0.4 for correlation is being set, 7features are obtained fromComparative Group 1, 8 features from Comparative Group 2 and 4 features from Comparative Group 3.The correlation matrix showing the selected features for Comparative Group 1, Comparative Group 2 and Comparative Group 3 is summarized in Table10, Table 12 and Table 14respectively. The "Super Reduced Feature Set" for the three Comparative Groups is listed in Table 11, Table 13 and Table 15.

Table 10:Feature Selection using Correlation matrix (ComparativeGroup 1)

S.NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1																
2	0.78519	1															
3	0.032765	-0.18193	1														
4	0.246365	0.358479	0.24162	1													
5	0.264326	0.489834	0.27795	0.856412	1												
6	-0.10557	0.054748	0.231	0.499212	0.455004	1											
7	0.044202	0.269801	-0.2339	-0.02993	0.221539	-0.01887	1										
8	0.155566	0.057281	-0.0403	-0.54416	-0.28774	-0.5081	0.164722	1									
9	-0.18356	-0.28219	0.09986	-0.1942	-0.1811	0.084789	-0.10732	-0.10251	1								
10	-0.31226	-0.174	-0.0425	-0.09238	-0.0632	0.377195	0.120103	-0.13494	0.634626	1							
11	0.062691	0.010087	0.16274	-0.38413	-0.21599	-0.26226	0.288793	0.359871	0.107074	0.116093	1						
12	-0.07571	-0.24287	0.52672	-0.18487	-0.13048	-0.09057	0.021046	0.270063	0.366271	0.204614	0.431978	1					
13	-0.09863	-0.02119	-0.2765	-0.20317	-0.10894	-0.09397	0.236812	0.356759	0.214473	0.341443	0.374904	0.257291	1				
14	0.318911	0.38481	0.07736	0.556382	0.592645	0.307372	0.285394	-0.1527	-0.11636	-0.04812	0.056159	-0.20051	-0.0871	1			
15	-0.13003	0.066323	-0.4422	-0.14653	-0.14113	-0.00142	0.298333	0.127856	0.178263	0.415135	0.192935	0.140409	0.7368	-0.05006	1		
16	-0.13956	-0.32052	0.3505	0.333828	0.144613	0.380266	-0.34724	-0.5049	-0.05387	0.087982	-0.323	-0.21975	-0.25963	0.234939	-0.30516	1	
17	-0.39644	-0.43065	0.17512	-0.1211	-0.10247	0.182688	0.023953	0.097274	0.254967	0.141848	0.261668	0.576538	0.258073	-0.11772	0.108715	-0.20463	1

Table11:Super Reduced Feature Set (Comparative Group 1)

S.NO	Features
1	Left index e/a average
2	Left ring b/a average
3	Right index d/a average
4	Right index b/a standard deviation
5	Right ring d/a standard deviation
6	Left index d/a standard deviation
7	Right middle d/a standard deviation

Table 12:Feature Selection using Correlation matrix (ComparativeGroup 2)

S.NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1																	
2	0.527474	1																
3	0.946451	0.04269	1															
4	-0.08239	0.0332	-0.09113	1														
5	0.31008	-0.02878	0.29724	-0.01684	1													
6	-0.25524	-0.39227	-0.24086	-0.04014	-0.37813	1												
7	-0.14557	0.20756	-0.11609	0.72871	-0.33185	0.05943	1											
8	-0.04852	0.33903	0.04731	0.22678	0.1201	-0.13941	0.19369	1										
9	-0.04718	-0.06867	-0.08271	-0.15852	-0.3741	0.18466	-0.02456	-0.06523	1									
10	-0.09655	-0.02046	-0.01635	0.22165	-0.19532	-0.26602	0.48488	0.03434	0.33191	1								
11	0.1679	-0.04148	0.11111	0.4203	-0.25436	0.00217	0.23002	-0.25981	0.21438	0.01944	1							
12	0.15882	-0.00024	0.10219	0.01664	0.59427	-0.37921	-0.17002	0.39682	-0.11735	-0.12769	-0.04019	1						
13	-0.09504	0.019757	-0.13393	-0.31127	-0.12962	-0.07047	0.047475	0.07056	0.32649	-0.03239	-0.33152	0.05331	1					
14	-0.00246	-0.21243	-0.04784	-0.00894	0.08006	-0.11008	-0.10417	-0.0727	-0.28629	-0.154	0.29814	0.08813	-0.1314	1				
15	0.82628	0.56321	0.85144	-0.14477	0.16192	-0.25737	-0.07692	0.0917	-0.14703	0.00794	-0.01433	0.13424	-0.08931	0.03991	1			
16	-0.32546	-0.26102	-0.38709	0.11013	-0.42545	0.5647	-0.07423	0.09759	0.12901	-0.35229	0.16507	-0.34845	-0.23081	-0.08591	-0.32518	1		
17	-0.09389	-0.21782	-0.10789	0.31042	-0.22029	0.63887	0.36414	-0.12398	0.07959	0.03094	0.11879	-0.45232	-0.24159	-0.07049	-0.05081	0.53424	1	
18	0.16443	0.25855	0.15102	0.79159	-0.07595	-0.1303	0.76449	0.21874	-0.11124	0.21758	0.42605	0.05283	-0.05201	-0.11845	0.14334	-0.01955	0.28212	1

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Table 13: Super Reduced Feature Set (Comparative Group 2)

S.NO	Features
1	Left middle d/a standard deviation
2	Left index d/a average
3	Right ring e/a standard deviation
4	Right index b/a average
5	Right index b/a standard deviation
6	Right ring b/a average
7	Left index c/a standard deviation
8	Left ring c/a standard deviation

Table 14: Feature Selection using Correlation matrix (Comparative Group 3)

S.NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1																	
2	0.544641	1																
3	-0.15653	-0.065383	1															
4	0.450479	0.769838	-0.386635	1														
5	0.378331	0.48873	-0.411344	0.717578	1													
6	0.596108	0.676095	-0.298819	0.634251	0.699717	1												
7	0.490032	0.257773	-0.152244	0.216234	0.017527	-0.006998	1											
8	-0.03824	0.198495	-0.068647	0.149546	0.368639	0.11274	0.0839963	1										
9	-0.06475	0.181229	0.472377	-0.275926	-0.442898	-0.217189	0.2236726	0.0831876	1									
10	0.41616	0.57531	-0.227547	0.731733	0.852922	0.680817	-0.029168	0.0439929	-0.4340562	1								
11	0.404182	-0.089805	-0.338751	-0.173485	-0.079782	0.287642	-0.034266	-0.251227	-0.0924403	-0.1071804	1							
12	-0.19864	0.021773	-0.152605	0.275672	0.627349	0.294106	-0.262572	0.4232886	-0.2598074	0.4081817	-0.145574	1						
13	0.18282	-0.19035	-0.227633	-0.29495	-0.160108	0.113899	-0.104507	-0.274172	-0.045815	-0.2384063	0.7857117	-0.076695	1					
14	-0.03843	-0.133633	-0.05443	-0.042922	-0.340043	-0.28825	-0.017564	-0.071709	0.0260351	-0.3261834	0.3709315	-0.050092	0.3742742	1				
15	-0.21282	-0.088096	-0.071538	-0.029554	0.298708	-0.103209	-0.020571	0.5737742	0.0357931	-0.0427359	-0.192229	0.6143269	-0.080112	-0.012333	1			
16	-0.11651	-0.029601	-0.152466	0.04046	-0.179111	-0.296797	0.2507063	0.0146181	0.083516	-0.2311256	-0.028501	-0.046393	0.184013	0.6608529	0.1213322	1		
17	0.064746	-0.1627	-0.065032	-0.079909	-0.180318	-0.156983	-0.081784	-0.044969	-0.098408	-0.2723735	0.3287013	-0.003644	0.4845167	0.8129649	0.1342289	0.5466087	1	
18	-0.097	-0.22335	-0.188637	-0.069572	0.26579	0.007437	-0.266931	0.5070144	-0.2173217	-0.1026148	0.0445957	0.450415	0.1510464	0.19408	0.6214262	0.051092	0.5348299	1

Table 15: Super Reduced Feature Set (Comparative Group 3)

S.NO	Features
1	Left index d/a average
2	Right index b/a average
3	Left middle b/a standard deviation
4	Right index d/a standard deviation

CONCLUSION

For detection of Enhanced Pitta in the three Comparative Groups, a "**Gross Feature Set**" of 48 acquired features from APG signal is taken. Reduction in number of features for all three Comparative Groups is made on the basis of (i)Threshold value of '0.25' of FDR to arrive at "**Truncated Feature Set**" (ii) Threshold value of 0.6 of correlation to arrive at **"Reduced Feature Set"** (iii) Threshold value of 0.4 of correlation to arrive at "**Super Reduced Feature Set".** The number of features selected in these sets for the three Comparative Groups is given in Table 16.

Table 16: Selected features for enhanced Pitta Detection

Feature Set	**Number of Features**		
	Comparative Group 1	**Comparative Group 2**	**Comparative Group 3**
Gross Feature Set	48	48	48
Truncated Feature Set	17	18	18
Reduced Feature Set	12	12	9
Super Reduced Feature Set	7	8	4

SCOPE FOR FUTURE RESEARCH

For our subsequent research communication,we shall be using the reference of the Table 16 to design and validate High Pitta Classifier using different classification techniques like Artificial Neural Networks (ANN), LIBSVM etc.The objective of our research shall also include suitability of "Truncated Feature Set", "Reduced Feature Set" or "Super Reduced Feature Set" of features for the best results.

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